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"CONSERVATION OF WILD LIFE THROUGH EDUCATION"

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A STUDY OF NESTING CANADA GEESE IN HONEY LAKE VALLEY, CALIFORNIA[1]

By Jay S. Dow

Bureau of Game Conservation
Division of Fish and Game

The Canada goose (*Branta canadensis canadensis*) commonly referred to as the "Honker" is the only species of wild goose that nests as far south as California.

According to Moffitt it breeds commonly in northeastern California, the normal breeding range closely paralleling the summer range of the Rocky Mountain mule deer in California. It is known to breed throughout Modoc and Lassen counties, wherever conditions are favor-

Fig. 1. Goose with newly hatched brood. The background is typical of the meadow land in the study area. Photograph by James D. Stokes.

able; in parts of Siskiyou, Tehama, Shasta, Plumas, and Sierra counties; and regularly to the southern end of Lake Tahoe. It has been reported as breeding occasionally at Mono Lake, Mono County.

During the nesting seasons of 1939 and 1940 a study was made of breeding Canada geese in Honey Lake Valley, Lassen County. The study was a part of a general survey of all waterfowl breeding areas in northeastern California conducted in 1939 by James D. Stokes and

[1] Submitted for publication, October, 1942.

the writer. Shortly after the survey began it became apparent that a detailed study of waterfowl nesting requirements would be necessary before effective steps could be taken to improve conditions for geese in northeastern California. Consequently, the writer was assigned to

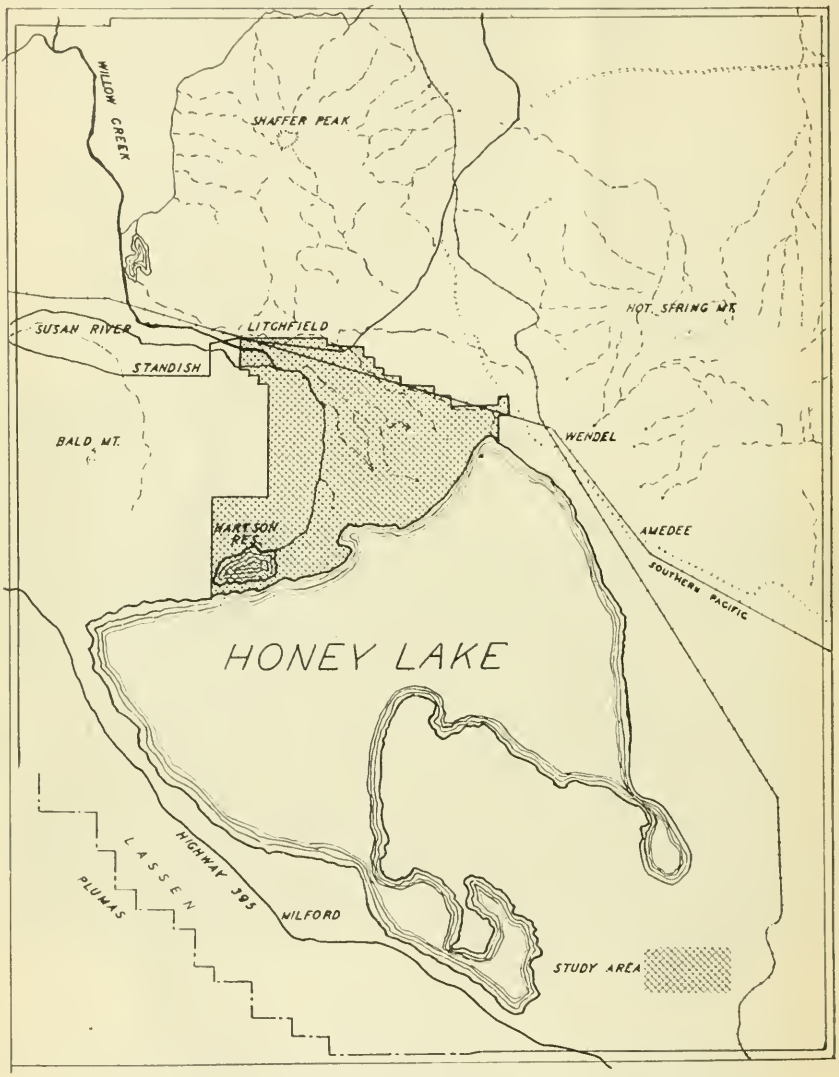

FIG. 2. Honey Lake Valley showing Canada goose study area.

the task of making a thorough nesting study of one of California's most important species of resident waterfowl, the Canada goose.

Probably no other area in California, with the possible exception of the Pit River Valley in Modoc County, supports so large a nesting population of Canada geese as does Honey Lake Valley. It is situated in southeastern Lassen County east of the town of Susanville

and lies at an altitude of approximately 4,000 feet. It is watered by the Susan River, Willow Creek, and numerous lesser tributaries. Honey Lake itself, covering an area of 64,000 acres, occasionally dries up, but it was full or nearly full during the period covered by this report.

Many species of ducks nest here, the most common being the mallard, and pintail, with lesser numbers of gadwall, cinnamon teal, redhead, and shoveller. The blue-winged teal and widgeon, which nest rarely in California, have also been known to breed here. The common shorebirds are the Wilson snipe, long-billed curlew, western willet, avocet, Wilson phalarope, and the killdeer.

The study began on March 16, 1939, and continued until July 1st. It was resumed on February 20, 1940, and continued until July 1st of that year.

Case histories were obtained on 169 nests in 1939 and 249 in 1940. The increase in the number of nests located during the second year of the study was due primarily to an increase in the population of breeding birds.

During 1937, a similar study was made by Williams and Marshall (1937) on the Bear River marshes in Utah. Although the conclusions drawn by the writer are in many cases in entire agreement with those of Williams and Marshall, the differences in the environmental factors of the two areas resulted in definite contrasts.

The project was under the direction of Joseph S. Hunter, Chief, Bureau of Game Conservation, California Division of Fish and Game, to whom thanks are due for his interest and assistance. Acknowledgments are also due to James D. Stokes who assisted in the field work in 1939, to James Moffitt, Gordon H. True, Jr., Howard Twining, and to many others who offered valuable advice and helped in the arrangement of this paper.

Procedure

An area of 15,560 acres on the north side of Honey Lake was chosen for study (Fig. 2). This area was selected because it includes all of the habitat types characteristic of the valley as a whole and, in addition, because in the future it will offer opportunity for the eventual application of management practices.

Most of the geese nest within this area which is known by residents as the "Tule District." It contains a few cultivated fields, but for the most part is devoted to grazing and the growing of wild meadow hay.

Approximately half of the study area was actually used by breeding geese. Seven thousand, one hundred and sixty acres were not used as nesting grounds. In the area remaining, the nests were generally found in groups, the location of the groups being correlated with the distribution of favorable nesting sites. Hence, it was possible for one man to inspect the nesting areas with little difficulty.

To facilitate the mapping of nest locations and the recording of data, the study area was subdivided into small work units varying in size from 160 to 2,000 acres. Nests were located by a systematic search of each work unit. Most of the nest hunting was done on horseback, although in lake and marsh areas it was necessary for the observers to use a small boat or wade.

The writer is convinced that he located more than 90 per cent of the nests in the study area, and it is possible that he actually located close to 100 per cent of them.

As each nest was discovered, its location was spotted on a map and complete data concerning it were recorded in field notebooks to be transferred later to a nesting record form (Fig. 3). Each nest, with a few exceptions to be noted later, was revisited at intervals of not more than six days until its fate was determined.

Nest number	Work unit	Cover type	Date found	Total eggs	Successful	Unsuccessful	Undetermined	Cause of failure								Additional remarks
								Coyote	Skunk	Crow	Cattle	Fire	Water	Deserted	Miscell.	
1	IV	A	3/17	4		√			√							
2	X	G	3/25	7		√		√								
3	V	D	3/25	7	√											1 egg infertile
4	V	B	3/28	6		√								√		Eggs covered ♀ never returned
5	VII	B	4/ 6	2			√									
6	VII	F	4/ 6	2	√											
7	VIII	H	4/ 7	6		√							√			
8	II	C	4/ 9	6	√											1 dead embryo
9	IV	G	4/ 9			√				√						
10	I	D	4/ 9	6	√											Hatching 5/3
11	IX	A	4/ 9	3		√					√					
12	VIII	E	4/10	6		√							√			High spring run-off
13	VIII	E	4/11	4		√									√	Farm machinery
14	VI	A	4/12	10	√											Double nest 3 dead embryo
15	III	A	4/12	5		√						√				Tules burned by ranchers

FIG. 3. Sample nesting record form.

Nests in the study area were easily found. Often several incubating birds were visible from one point of vantage. The geese nest in early spring when the grass in the flat, open meadows is so short that the nest mounds can often be seen from a distance of 100 yards or more. Also, a nest can nearly always be located by observing the solicitous males. The gander usually stands in the vicinity of the nest while the female is incubating and protests loudly at the observer's approach.

Nesting Dates

The nesting season was already well under way when the study began on March 16, 1939. Nests with eggs were most numerous by the middle of April (Fig. 4). By May 10th, all breeding activities had

ceased with the following exception. On March 27, 1939, a nest containing six eggs was found on top of a haystack. On April 20th, the incubating bird was disturbed by photographers and left the nest for approximately two hours during the heat of the day. The goose continued to incubate until June 22d, when the writer took the eggs for examination. They all contained well-developed embryos which were dead, probably as a result of their prolonged exposure to the sun on April 20th. To the writer's knowledge the goose had incubated for 87 days.

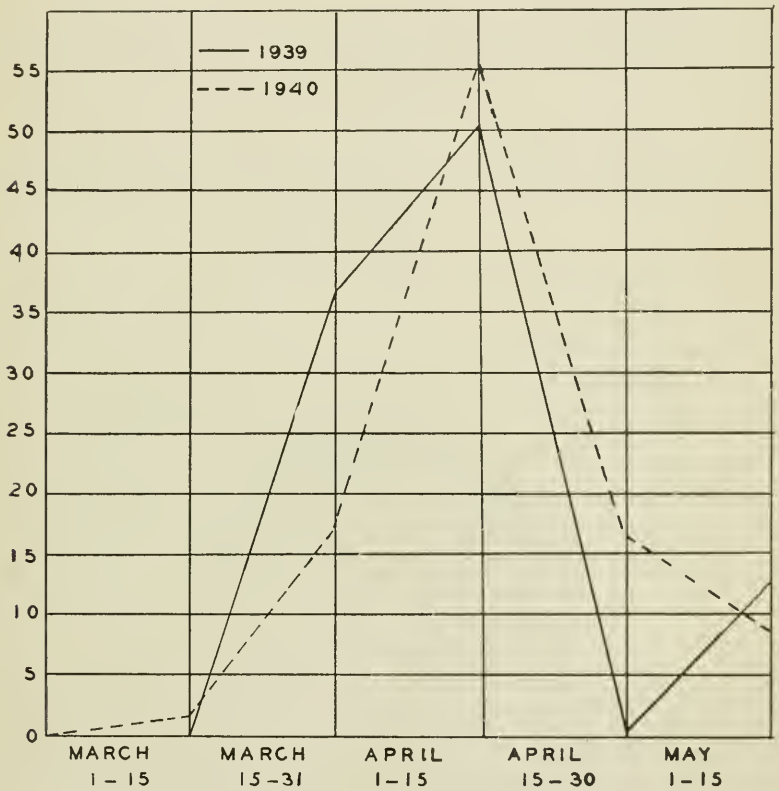

FIG. 4. Occurrence of nests during the 1939 and 1940 seasons by bi-weekly periods.

In 1940, the first nest was discovered on March 6th. As in 1939, April 15th marked the approximate peak of the nesting season. The nests were visited for the last time on May 10th, by which date all of the broods had left the nests.

In 1939, 140 nests were located containing 713 eggs, or an average of 5.09 eggs per nest. In addition, 29 nests were discovered after they had been destroyed or after the broods had hatched. In 1940, 215 nests were found containing 1,099 eggs, or 5.10 eggs per nest, and, in addition, 29 nests were discovered after they had been destroyed or after the broods had hatched. The average clutch size for 127 success-

ful nests in 1940 was somewhat higher with an average of 5.48 eggs per nest.

The average incubation period for Canada Geese nesting in their natural habitat is 28 days. This corresponds closely with reports from E. D. Platt at the State Game Farm at Chino, California, who has bred honkers in captivity for many years.

The distances of the nests from each other usually depended upon the strength and fighting ability of the ganders. Several especially pugnacious ganders were successful in keeping other nesting geese more than 150 yards from their incubating mates, while other pairs of geese were found to be nesting within 10 to 12 feet of one another without the slightest indication of fighting.

Nesting Sites

The one characteristic that nearly every nest studied had in common was elevation above the surrounding terrain. Elevated sites offer a clear view of the surroundings and afford protection from floods,

FIG. 5. Pair of nesting geese on haystack. Photograph by James Moffitt.

grazing live stock, and farm machinery. By increasing the field of vision these also afford the incubating geese some protection against predation. This supposition is borne out by the fact that during the course of the study only one adult goose was found killed on the nest by a predator.

Ninety per cent of the nests were either surrounded by water or were within thirty feet of a lake, ditch, or flooded meadow. Nests in such locations were usually elevated well above the water level. Muskrat houses, mats of tules in dense clumps, or mounds of tule stems built up by the geese aided in elevating the nests.

After the eggs have hatched, the goose usually broods her young in the nest for twelve to twenty-four hours. The young are then led to open water, usually a lake or one of the deep canals, where the family remains until the young are able to fly. Hartson Reservoir (Fig. 2) is one of the favorite rearing areas in Honey Lake Valley, and during the course of this study, the margins of Honey Lake itself were used extensively. In some cases broods of geese traveled as far as four or five miles over marshy areas or along water courses in order to reach these large bodies of water.

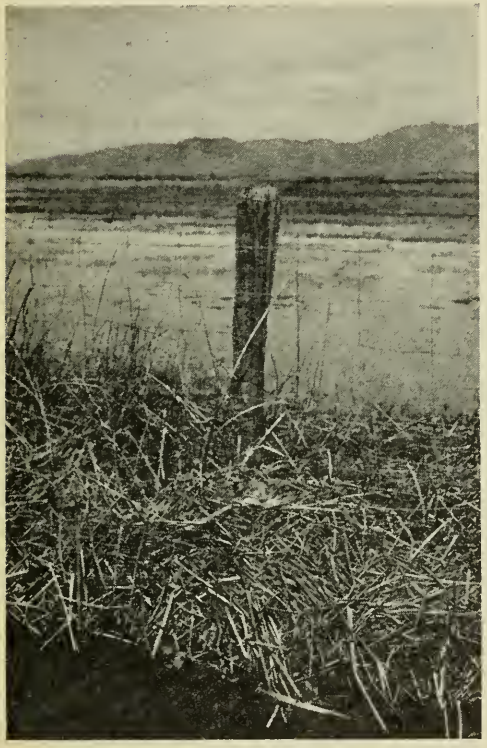

FIG. 6. Goose nest on canal bank. Canal in foreground, irrigated meadow in background. Photograph by James Moffitt.

Haystacks (Fig. 5), canal banks (Fig. 6), muskrat houses, matted masses of tules (Fig. 7), and sand islands were among the preferred nesting sites. The extensive use of haystacks as nesting sites afforded the writer an opportunity to make the following unusual observations:

On April 14, 1940, the writer noticed a wagon load of hay which was stuck in the mud and abandoned temporarily by the owner. A nest containing six eggs was found on the exact top of the load at a height of 12 feet from the ground. When the nest was revisited a few days later, a mallard was found to be nesting on the same wagon within three feet of the incubating goose. Both were successful in hatching broods.

On March 18, 1940, a goose nest containing two eggs was found on the top of one end of a large haystack, more than 18 feet from the ground. Two or more wagon loads of hay were being taken from the opposite end of the stack each day. As the haystack decreased in size and the nest was endangered, the rancher considerately moved the nest and eggs to a safer position on the stack. By April 25th, the stack had dwindled to only a small pile and the nest was less than six feet from the ground. The farmer was obliged to move the nest to save the eggs from destruction each time he took hay from the stack. A last visit to the nest revealed that the goose hatched two goslings in spite of the fact that she had been disurbed each day during the incubation period. The incubation period, in this case, was approximately 33 days.

Nest Material and Construction

When a variety of nest material is available the nests are usually well made, but when the site is in a locality that is devoid of vegetation such as a canal bank or sand island, the nest is often little more than a depression scratched in the ground and lined with down from the goose's breast (Fig. 8).

In marshy areas where round-stemmed tules (*Scirpus acutus*) and three-square tules (*Scirpus paludosus*) are abundant, geese frequently build nest mounds, often piling tule stems as high as three feet above the ground or water level before beginning the construction of the nest proper. Many of the tule stems used in the mounds or in nest construction are broken from growing stalks. In some cases, areas

FIG. 7. Typical mass of round-stemmed tule (*Scirpus acutus*), a favored nesting site. Photograph by James Moffitt.

surrounding nests were denuded of tule growth for distances of from three to 10 feet.

When nests are built on haystacks, tule mats, muskrat houses, or nest mounds, they are carefully constructed. A neat oval-shaped depression is usually made, 12 to 14 inches long, 8 to 10 inches wide, and 5 to 8 inches deep. The actual construction of the nest usually continues during the laying period, frequent additions being made until about the beginning of the period of incubation. It is not until this time that the nest is finally lined with down.

When the female leaves the nest for the feeding grounds, she carefully covers the eggs with down from the nest lining. The down is an effective insulator; nests that have been left voluntarily by the incubating female on cool days have been found to contain warm eggs two hours after she had left the nest. On hot days the down also acts as an insulator against the heat of the sun.

Flushing Distance

Williams and Marshall (1937) report that average flushing distance during the early part of the nesting season, in April, was roughly 50 feet, and that nearly a month later the distance was reduced to an average of approximately 32 feet.

Although the writer did not keep a detailed record of flushing distances, it is safe to say that the average flushing distances were considerably less than those reported above. In fact, during the incubation period, it was possible for the observer to walk or ride to within five or six feet of many nests without flushing the goose.

FIG. 8. Goose nest on island in Hartson Reservoir photographed after incubation started. The goose has been disturbed so has not had time to cover eggs before leaving. Photograph by James Moffitt.

This difference in flushing distances is probably due to the fact that Honey Lake Valley is an agricultural area and the geese quickly become accustomed to the almost daily presence of human beings in the vicinity of their nests.

Nesting Types

Eight distinct cover types were used by nesting geese (Table 1), but there was considerable variation in the selection of sites within each type.

A. Tule: This type includes round-stemmed tule thickets bordering canals, sloughs, and lake shores, and clumps of round-stemmed tule located in the marsh or meadow types. In 1939, 43 or 25.4 per cent of the nests were found in this type, compared with 99 or 39.8 per cent in 1940, an increase of 14.2 per cent. In 1940, cooperating ranchers

left many patches of round-stemmed tule that ordinarily would have been burned. Thus, a greater amount of this cover type was available.

TABLE I

Cover Types Utilized by Canada Geese in 1939 and 1940 and Percentage Distribution of Nests

Cover Type	*1939* (169 nests)	*1940* (249 nests)
A. Tule	25.4	39.8
B. Marsh	30.8	6.8
C. Island	12.4	20.9
D. Haystack	2.4	5.6
E. Irrigated Meadow	10.1	8.4
F. Muskrat House	7.7	0.4
G. Canal Bank	11.2	16.1
H. Willow	0.0	2.0

B. Marsh: The areas designated as marsh were those areas that were flooded during the spring season, or, if water were available, remained flooded the year around. They were distinguished from Type E (Irrigated Meadow) by ranker plant growth and the fact that they were never mowed, but instead grazed by live stock during the dry season. [Types A (Tule) and F (Muskrat Houses) were located within this type and could be considered as subtypes of Type B.]

In 1939, 52 nests or 30.8 per cent were found in this nesting type. In 1940, only 17 nests or 6.8 per cent were found here. This marked decrease was due to the unusual high water levels that prevailed during the 1940 nesting season, forcing the nesting geese to higher and drier elevations.

C. Island: Only 30 acres of islands were included in the entire study area, a fraction of 1 per cent of the total acreage. The fact that 21 nests or 12.4 per cent were found in Type C in 1939, and 52 nests or 20.9 per cent in 1940, indicates that islands are preferred nesting sites.

The increase in the use of this type in 1940 was probably due to the prevalence of high water in other nesting areas. Also, the higher water level resulted in there being more islands.

D. Haystacks: Haystacks were used as nesting sites by four pairs of geese or 2.4 per cent in 1939, and by 14 pairs or 5.6 per cent in 1940.

The use of haystacks as nesting sites is directly correlated with the amount of hay used for winter feeding of live stock. Most of the stacks that were still present during the nesting seasons of 1939 and 1940 were used by nesting geese.

E. Flooded Meadows: This type is similar to Type B (Marsh) in that it is ordinarily flooded during the nesting season.

On the flooded meadows, however, water is under control. They are drained during June and July so that grasses and sedges can be harvested. In this type there are levees, dams, and occasional plots of high ground which afford nesting sites for geese.

Seventeen or 10.1 per cent of the nests were found in meadows in 1939 and 21 or 8.4 per cent in 1940.

F. Muskrat Houses: Thirteen nests or 7.7 per cent were found on muskrat houses in 1939 and only 1 or 0.4 per cent in 1940.

Muskrats are heavily trapped in this area and permanent water is scarce, so the number of muskrat houses is limited. All of the muskrat houses were found within Type B.

G. Canal Banks: This type was used commonly in the study area. Nineteen nests or 11.2 per cent were found on canal banks in 1939, and 40 nests or 16.1 per cent in 1940. Although canal banks in the study area had little cover, they are evidently preferred because they afforded the desirable combination of elevation plus visibility.

H. Willow: It was evident that the dense willow thickets that dot the Honey Lake Valley landscape are not preferred nesting sites. No nests were found in this type in 1939, but in April 1940, when high water decreased the use of some of the other types, 5 nests or 2 per cent of the total were found in willows.

It is interesting to note that none of the nests located in this type were successful.

Fate of Nests

In the course of the study the fate of 418 nests was determined. Each nest was visited at intervals of not more than six days until its fate was determined. The findings are shown graphically in Fig. 9.

The writer recognizes the fact that the presence of an observer in the field can, in itself, affect the rate of nesting success. His presence, for instance, can cause an increase in the percentage of desertions. The frequent flushing of birds from the nests and the trails left as a result of his visits can cause an increase in predation losses.

It is felt, however, that in the case of this study, the writer's activities had little effect on the total results. Persons other than the writer were present in the area daily. In fact, many nests were reported by ranchers who found them during the course of normal farming operations. Consequently, the writer's presence added but little to the normal hazards associated with agricultural use.

Successful Nests

In 1939, 52.5 per cent of the nests were successful. In 1940, broods were successfully hatched from 60 per cent.

Successful nests were recognized by their appearance after the eggs were hatched. In nearly all cases the shells of the hatched eggs were crushed, presumably by the parent during the period that elapsed between hatching and leaving the nest. Only bits of shell and the crumpled inner shell membranes remained. In a few cases nests were torn up by predators after the eggs had hatched out, but the characteristic remains of hatched eggs were still present to indicate success.

Unsuccessful Nests

Desertion: In 1939, 11 or 6.5 per cent of the nests were deserted, compared with 18 or 7.3 per cent in 1940.

Of the 29 nests deserted during the two year period, 14 were abandoned for unknown causes. Nine nests were deserted as the result of fighting among geese in areas where nests were placed close together. In several instances an observer watched ganders fighting over nesting

sites, and in nine cases the desertions of nests were traced directly to this cause.

Six desertions were directly traced to man's activities. The disturbances of irrigators traveling the canal banks with their dogs were responsible for five, and one was deserted when the writer flushed an incubating goose from her nest while two crows were circling overhead. Believing that the nest might be destroyed by these birds, the writer carefully covered the eggs, but the goose never returned.

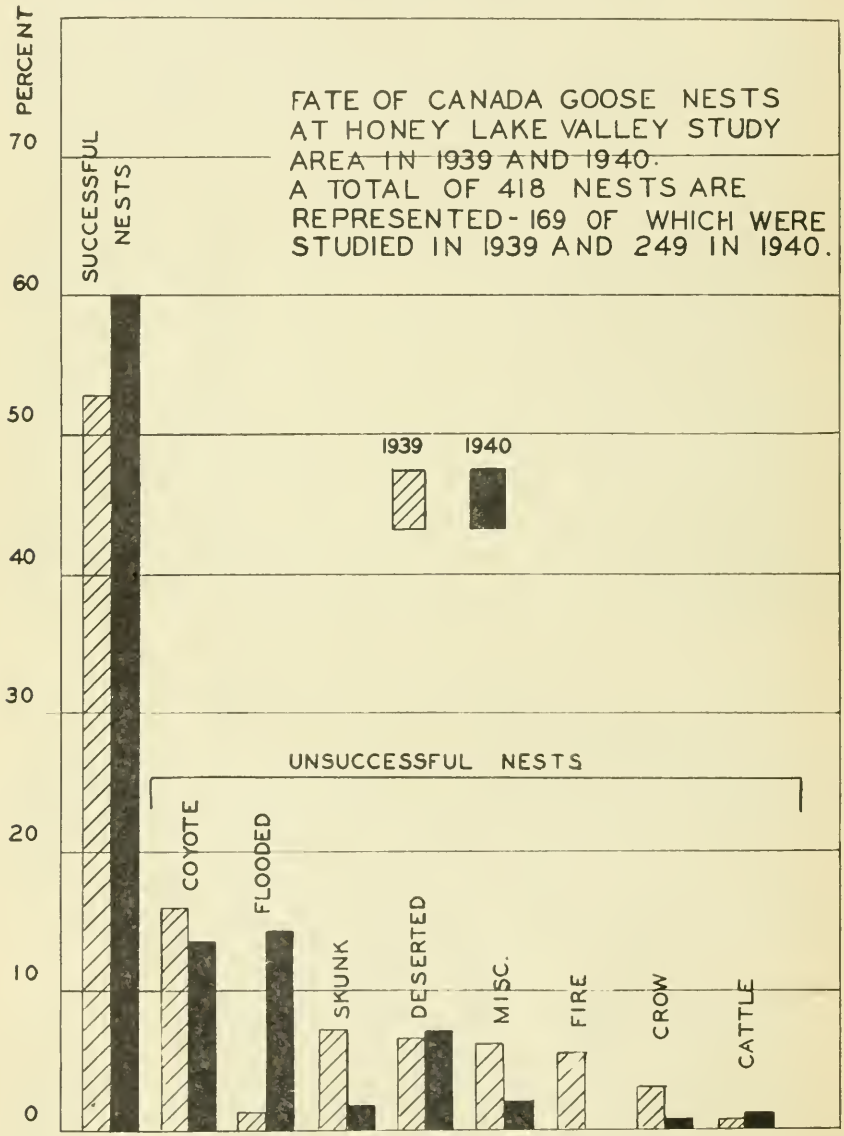

FIG. 9

Nest Destruction by Predators

It is not always easy to place the responsibility for nest destruction upon one particular predator. Most kinds of predators do, however, leave characteristic signs that may be accurately interpreted by an experienced observer. The manner in which different predators rob nests and eat eggs is often characteristic. Tracks, droppings, hair, and feathers all constitute dependable evidence.

Coyote: Coyotes were responsible for more nest destruction than were all other predators combined. A total of 59 nests were destroyed by coyotes on the study area during the two seasons; 27 nests or 16 per cent in 1939, and 32 nests or 13.3 per cent in 1940. In 1940, one goose was killed on her nest by a coyote.

FIG. 10. Goose nest destroyed by coyote in Honey Lake Valley. Note scattered egg remains and torn up nest lining. Photograph by James D. Stokes.

The methods employed by coyotes are characteristic and consequently their work is readily identifiable. Eggs eaten by coyotes in all cases were found crushed to bits. Nests were always completely destroyed, and the down lining was scattered in all directions (Fig. 10). In several instances eggs with typical large canine tooth holes in them were found 50 to 75 feet or more from destroyed nests.

An extreme instance of coyote predation is illustrated by the case of a coyote that waded and swam 50 yards to a sand island, ate 12 eggs from two nests, then scratched sand over five more nests with eggs, causing the geese to desert.

Of the nests destroyed by coyotes, 46.8 per cent were on islands, 31.3 per cent in meadow, 12.5 per cent in tule, and 9.4 per cent in marsh.

Skunk: Skunks are masters of the art of egg eating and their work is easily identifiable. The skunk makes a hole in the egg large enough to admit its pointed nose, then licks out the contents. The eggs are either rolled a few feet from the nest before being eaten or are eaten in the nest. The lining of the nest is not torn to bits as it is in the case of a coyote, and tracks are usually in evidence. A skunk will ordinarily eat only two or three eggs from one nest. In no case was there evidence that a skunk returned to a raided nest for a second meal.

Skunks were responsible for the destruction of 12 nests or 7.1 per cent in 1939, and 4 nests or 1.6 per cent in 1940.

Crows: Crows destroyed 6 or 3.5 per cent of the nests in 1939, and 2 or .8 per cent in 1940.

Crows ordinarily peck one or two holes in the shell of an egg and only remove a part of the contents. Bits of shell are generally found stuck to the surface of the egg. A number of eggs were eaten by crows after the eggs had been scattered and cracked by other predators, but these are not included in the above figures.

Other Losses

Water: Many nests were flooded during periods of excessive spring run-off. Also, the strong winds that sweep across Honey Lake and adjacent smaller bodies of water drove the waves high over the normal shore line, washing out nests that were located near to water margins.

During 1939, there was no high water and losses traceable to flooding consequently were small, amounting to only 2 nests or 1.2 per cent. In 1940, high water occurring during the last few days of March destroyed 35 or 14.1 per cent of the nests under observation.

Fire: Fire destroyed 10 nests or 5.9 per cent during the 1939 season. The ranchers in Honey Lake Valley attempt to control the growth of round-stemmed tule by winter and spring burning. All of the nests destroyed by fire in 1939 were located in tule masses. In 1940, the ranchers, who proved to be a very cooperative group, completed the burning program before the beginning of the nesting season and no nests were destroyed.

Cattle: The number of nests destroyed as the result of trampling by cattle was small; 2 or 1.2 per cent in 1939, and 4 or 1.7 in 1940.

Hundreds of cattle were grazed on the study area during the nesting season, but most of the nesting sites were located in areas that were not heavily grazed.

Miscellaneous: Fifteen nests were destroyed during the two-year period by what the writer chooses to call miscellaneous causes. Ten or 6 per cent were so destroyed in 1939, and 5 or 2 per cent during 1940.

Three nests listed as destroyed by farm machinery were broken up by drags used by the farmers to smooth out meadows. One was destroyed indirectly when a mink tore up a muskrat house on which the nest was placed. Another nest located on a muskrat house was destroyed when the rats worked up through the bottom of the nest, allowing the eggs to drop into the house cavity. As noted earlier in the paper, another nest was destroyed as the result of exposure to the sun. One goose was found dead on her nest. The Poultry Pathological Laboratory of the University of California determined the

cause of death to be aspergillosis, a fungus infection of the respiratory tract.

The cause of eight unsuccessful nestings was undetermined.

Egg Fertility

During the 1940 season, a record of egg fertility was kept on 127 successful nests. These nests contained a total of 697 eggs or an average of 5.48 eggs per nest. Six hundred and forty-nine or 93 per cent of the eggs produced goslings.

Williams and Marshall (1937) reported an average clutch of 4.8 eggs and a hatch of 81 per cent for a total of 84 nests and 410 eggs.

Of the 48 eggs that did not hatch, 16 or 33.3 per cent were infertile. In 17 or 35.3 per cent there were partially developed embryos, and in 15 or 31.4 per cent of the eggs the goslings were well developed but had died before hatching. In each of the latter cases, the yolk sac was still unabsorbed.

Three unhatched eggs were found in each of three successful nests. These eggs all contained dead, partly-developed embryos. No doubt these eggs were deposited by another female goose after incubation of the original clutch had started, and the extra eggs were abandoned after the original clutch had hatched.

With the exception of the three cases noted above, all of the other unhatched eggs were found singly.

Management

It is possible that through the application of management methods the number of geese produced annually in Honey Lake Valley may be increased.

The control of predators, particularly coyotes, in the prenesting season will prove to be an effective management tool. Some coyote control work is being carried on in the valley at the present time, but it is not intensive enough to give the required amount of protection to the geese during the nesting season.

Where it is practicable and compatible with the other interests of an agricultural community, the more efficient control of water levels will result in the elimination of losses due to the flooding of nesting sites.

The writer has already mentioned that losses due to fire were prevented in 1940 by inducing ranchers to complete tule burning operations prior to the nesting season. The continuance of this practice should be encouraged. In view of the cooperative attitude of the ranchers, it may also be possible to eliminate losses caused by drags used to level meadow land during the spring months and by ditch and levee cleaning operations.

It is important that tule masses, which are favored nesting sites, be left unburned where their presence will not interfere with farming operations. Additional nesting sites may be provided by the construction of islands in Hartson Reservoir and along the margins of Honey Lake.

Summary

1. A study was made of nesting Canada Geese on a 15,560 acre area in Honey Lake Valley, California, in 1939 and 1940. Case histories were obtained on 169 nests in 1939 and 249 in 1940.

2. During both years the nesting season began about March 1st, reached its peak by April 15th and ended by May 10th.

3. In 1939, 140 nests contained 713 eggs; an average clutch of 5.09. In 1940, 215 nests contained 1,099 eggs; an average of 5.10. The average incubation period was 28 days.

4. Elevation above surrounding terrain seemed to be the most important characteristic of nesting sites. Proximity to water was another important requisite, 90 per cent of the nests being either surrounded by or not more than 30 feet from water.

5. Eight distinct cover types used by nesting geese were recognized. These were tule, marsh, island, haystack, irrigated meadow, muskrat house, canal bank, and willow. Tule, marsh, island, and canal bank were the preferred types.

6. The fate of 418 nests was determined. In 1939, 52.5 per cent and in 1940, 60 per cent of the nests were successful. Predation was responsible for the failure of the majority of unsuccessful nests. Flood, fire, trampling by cattle, and other miscellaneous factors also caused the destruction of nests.

7. During 1940, a record of egg fertility was kept on 127 nests containing 697 eggs; an average clutch of 5.48. Six hundred forty-nine, or 93 per cent of the eggs hatched.

8. The application of management methods in Honey Lake Valley should result in a larger annual crop of geese. The control of predators, particularly coyotes, during the prenesting season, the regulation of water levels, and the control of fires are methods that will produce immediate results.

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TWELFTH ANNUAL BLACK BRANT CENSUS IN CALIFORNIA[1]

By James Moffitt
California Academy of Sciences

Because of the depletion of eelgrass on the Pacific Coast recorded in the 1941 brant census report (Moffitt, 1941), it was held desirable to conduct a census again in 1942 in spite of war conditions, in order to determine the status of the birds and the effect upon them of the shortage of this plant which normally forms their principal food. Cooperation of U. S. Army officials, which is hereby gratefully acknowledged, in permitting trespass upon restricted areas made it possible to carry on the census almost as satisfactorily as in previous years.

The censuses were obtained in 1942 on the customary date, February 10th, from all localities included in the past save Drake's Bay, where airplane activity precluded. The actual counting was carried out as usual by members of the Bureau of Patrol of the California Division of Fish and Game, and by interested individuals, mentioned beyond; this assistance is hereby sincerely acknowledged. In addition to counting the brant on the appointed date, the wardens reported upon the condition of eelgrass in their vicinities, not only at the time, but in many cases at other seasons of the year. The cooperators also collected samples of this plant which were sent to Dr. E. C. Renn for examination. The results of these reports and examinations are summarized later in this article.

The writer again supervised the census, which he started in 1931 when an employee of the State Division of Fish and Game. Due to his appointment as Lieutenant, U. S. Naval Reserve, in March, 1942, and his assignment to active duty in June, the completion of this paper has been delayed, and it is with great regret that an 11-year record is broken by failing to publish the report in the October issue of *California Fish and Game* following the census. For the same reasons, it will be impossible for him to continue the project until better times return, but it is hoped that even in these critical days those who have cooperated in the past, and who remain in their localities, may find it possible to record and publish some information upon the birds during what may become a crisis due to the eelgrass situation.

Results of the 1942 censuses in the various localities follow.

Humboldt Bay

Warden L. E. Lahr, who took the two previous censuses at this point, had been transferred, so Warden Laurence Werder undertook the 1942 count with highly successful results. Counting in clear weather with little wind and a falling tide, on South Bay from 8.00 to 10.00 a.m., and on North Bay from 11.00 a.m. to 1.30 p.m., Werder

[1] Submitted for publication, October, 1942.

concluded that a total of 48,000 brant was present of which two-thirds were found on South Humboldt Bay.

This number of brant is somewhat above the 10-year average for the period 1932-1941 at Humboldt Bay, but it is less than the 1940 and 1941 totals (see Table 1). Far fewer brant were reported at Humboldt Bay in several previous counts, however. The present census result plus Werder's report that he found no evidence of eelgrass depletion, indicates that the brant of this locality were in a satisfactory position.

Werder stated that the first brant observed at Humboldt Bay in the Autumn of 1941 were noted on October 12th. This is an early date for migrant arrivals and the individuals may possibly have been those that were reported as having bred there that Summer (Moffitt, 1941). Brant censuses made at Humboldt Bay on the three days, January 24-26, 1942, by Werder for the U. S. Fish and Wildlife Service, averaged 20,000 birds. The normal seasonal increase of brant locally from early January to peak numbers in March, which has been mentioned in previous census reports, is well indicated by Werder's observations in 1942.

Bodega Bay

For the fourth time Warden Bert Laws took the census in this locality. As previously, the count was made with telescope from shore, about midmorning. Most of the brant were found near the mouth of the bay and along the shore near the sand spit, where they were probably driven by the activities of boats in the upper bay. The total count was only 470 brant which compared unfavorably with a total of 555 birds counted in 1941 and with a previous 10-year average of 1,520 brant for the bay. Only once, in 1936 when 350 brant were counted, were fewer birds reported than in the present season. It is uncertain whether the increased amount of boating, fishing and other human activities, or depletion of eelgrass in Bodega Bay has contributed most to the decline in the numbers of brant that have visited the bay in recent years. Their numbers have declined steadily since 1937, but most markedly in the last two seasons, coincident with the eelgrass depletion.

In counting on Bodega Bay for the U. S. Fish and Wildlife Service annual waterfowl inventory, Warden Laws reported 560 brant present on January 24th, and 340 on January 26, 1942.

Tomales Bay

Gordon H. True, Jr., Bureau of Game Conservation, Division of Fish and Game, and the writer took the brant census on this bay from outboard motorboat from 8.15 to 10.40 a.m. of February 10, 1942. This was during a period of falling tide, high water having been at 7.38 a.m. The day was clear, calm and warm, providing good conditions for observation and it was judged that a reasonably accurate count was obtained. Most of the brant were found feeding in a large flock north of Hog Island. None were observed south of Nick's Cove, just south of Hamlet, where in some years large numbers have been counted; while very few birds, only 93 to be exact, were counted in the outer bay north of Tom's Point where many were noted in some of the

former counts. The 1942 total was 2,372 brant, a small number for the locality as contrasted with the previous 11-year average of 5,915; yet some improvement over the 1941 all-time low count of 1,540 birds was evidenced.

It was fortunate that the count was made early in the morning, for about 9.40 a.m., when we had just finished counting south of Tom's Point, two low flying Army airplanes came down the bay and greatly disturbed the brant. About an hour later, just as the census was concluded, these airplanes returned and all of the brant in the bay took to wing. The birds circled about in a large flock at considerable altitude, then after a few minutes when the planes had passed on, the brant alighted on their feeding grounds whence they had been frightened. It appeared that the airplane activities, unless too continued, would alarm them only for a short period, and would probably not drive them from the vicinity.

Warden Laws counted the brant on Tomales Bay for the Federal waterfowl inventory, January 24-26, 1942, when he estimated that the average number of birds present for the three days was 2,333. This figure is close to our total of 2,372 for February 10th.

Drake's Bay

Airplane activity that commenced just as Wardens Yates and Hardin arrived to take the census, frightened all of the brant out to the adjacent ocean, so that it was impossible to obtain a count in this locality. It is regretted that for the second consecutive season, it has been impossible to secure a census of the brant at Drake's Bay upon the appointed date.

Morro Bay

Warden F. W. Hecker and Dr. A. P. Marshall of San Luis Obispo again cooperated in taking the 1942 census in this bay on February 10th. Mr. Hecker reported that a satisfactory count totaling 8,861 brant was obtained in the calm, warm morning. The birds were found rather evenly scattered over the southern three-quarters of the bay, excepting for a concentration of about 1,800 at Grassy Island in the north central part, and another group of approximately 2,300 at the edge of the State Park tideflats between Cabrillo and El Moro points.

The 1942 census total in this locality compares favorably with the previous 10-years' average of 5,964 brant. In fact, the present figure was exceeded in the past only by the record count of 11,140 brant in 1939. Mr. Hecker remarked in reporting upon the present census that while the numbers of brant on Morro Bay fluctuated as usual from time to time throughout the Winter, it was his opinion that the average number of the birds present during the Winter of 1941-1942 was greater than the average for the past five years. He was not certain, however, if this condition was caused by an actual increase in the number wintering in the entire area including the San Luis Obispo County coastline, or by the fact that last Winter it appeared that most of the brant of the county were concentrated in Morro Bay.

After taking the present census at Morro Bay, Hecker and Dr. Marshall drove up the coast as far as Arroyo Cruz. The only brant that they saw on this trip were 50 flying north, about a mile west of

the mouth of Santa Rosa Creek. These birds were kept in view until they passed Piedras Blancas and continued on northward. This appeared to be a northward migratory movement.

Brant appeared at Morro Bay unusually early in the Autumn of 1941. The earliest arrivals reported were about 100 birds seen at Muma Beach, a mile south of Piedras Blancas Lighthouse on October 8, 1941. A week later, 200 brant were seen on Morro Bay.

Warden Hecker stated that the early brant noted at Muma Beach were the only birds reported seen along the San Luis Obispo County coastline during the past Winter. He said this condition was unusual for the area, for in past seasons the birds were commonly found feeding close inshore or resting on the beaches throughout the Winter in the area between San Simeon and Piedras Blancas. During the past Winter, apparently all of the brant of the region fed in Morro Bay. This information suggests that there was no acute shortage of eelgrass locally, else the brant would likely have fed to some extent, as they formerly did, along the ocean coast.

Warden Hecker reported that in his opinion the effect of defense and war activities upon the brant of the area was slight. He stated that patrol planes and firing by Coast Artillery units occasionally disturbed the birds, but that neither activity seemed to have any lasting effect upon them. When Hecker and Dr. Marshall returned to Morro Bay after their trip up the coast late in the afternoon of February 10th, the Coast Artillery did some practice firing near Hazard Creek, immediately south of Morro Bay. As soon as the firing commenced, the brant started flying out to the ocean, over the peninsula, and within 10 minutes there were none left in Morro Bay.

Point Mugu

This was the third census conducted in this locality, as observations were only commenced in 1940 (Moffitt, 1940). Warden R. E. Bedwell took the present, as well as the two previous censuses. Because so few counts have been made at Point Mugu, the results are not tabulated in Table 1, beyond.

Counting on February 10, 1942, Bedwell found 508 brant present. This number is contrasted with his 1941 total of 1,050 birds, and 1940 result of 500 brant on the same date in those years. In commenting upon the 1942 census, Bedwell reported that the brant arrived at Point Mugu much later than was usual in the preceding five seasons. In 1940, they arrived in numbers from about December 20th to the end of January, 1941. During the Winter preceding the 1942 census, the brant did not arrive until late January, and then they appeared but a few at a time. This condition, the exact reverse of that reported by Hecker for Morro Bay, a short distance to the north, is difficult to interpret, but may possibly have been due to deposits of silt over the eelgrass beds in the lagoon at Point Mugu, reported by Bedwell and mentioned beyond in this paper under eelgrass conditions.

Mission and San Diego Bays

Warden E. H. Glidden, who has cooperated for many years in brant censuses in the San Diego area, took the 1942 census on February 10th. He was assisted by L. M. Huey, San Diego Natural History

Museum, and by Earl Warren, San Diego Chapter, Izaak Walton League. The weather was clear and warm, visibility good, and the tide falling all morning. The brant in both bays were found to be scattered in compact rafts so that it was impossible to secure exact counts, however, the estimates made were judged by the observers to be conservative.

The 1942 totals for both bays were surprisingly large. In San Diego Bay, 750 brant were estimated present off the mouth of Sweetwater River and 350 birds along the bay's western shore, a mile south of Coronado. The total for San Diego Bay, hence, was 1,100 birds. This is more than twice the number reported in the previous highest census for the area, in 1939, when 462 were counted.

In Mission Bay, a total of 3,900 brant was estimated present. This result is also far in excess of the highest number, 2,500, reported in any of the previous 11 counts. Table 1 clearly indicates the steady and rapid repopulation of these bays by brant since 1932, when none was reported from either locality. Brant were abundant winter visitants to both bays 40 years ago, but as the census results of the years 1931-1936 indicate, they practically forsook the area for an interval. The rapid repopulation of the bays within the past six years, during a period of great human activity and development in the area, is one of the interesting facts that has been demonstrated by this series of censuses.

Brant arrived in San Diego Bay early in the Autumn of 1941. A hunter reported to Glidden having killed two brant from a flock of nine on October 18th. Glidden stated, however, that the birds did not commence to arrive in consequential numbers until after the season had closed, in mid-December, and that very few brant were killed locally.

TABLE 1

Recapitulation of California Black Brant Censuses, 1931-1942

Locality	1931	1932	1933	1934	1935	1936
Humboldt Bay	Unsatisfactory	29,415	5,000	16,860	105,000	50,000
Bodega Bay	None made	3,200	977	1,298	3,700	350
Tomales Bay	9,445	6,285	7,409	5,565	6,850	9,175
Drake's Bay	None made	2,108	318	2,189	1,995	1,500
Morro Bay	4,493	2,938	None made	3,895	7,544	5,000
Mission Bay	71	No birds	115	154	9	30
San Diego Bay	No birds	No birds	No birds	7	55	No birds
Totals	Incomplete	43,946	13,819	29,968	125,153	66,055

Locality	1937	1938	1939	1940	1941	1942
Humboldt Bay	22,500	45,000	29,000	56,375	50,000	48,000
Bodega Bay	1,500	1,475	1,100	1,050	555	470
Tomales Bay	1,556	3,085	9,241	4,916	1,540	2,372
Drake's Bay	1,500	3,500	6,400	4,400	None made	None made
Morro Bay	5,331	5,738	11,140	7,263	6,302	8,861
Mission Bay	450	325	570	1,395	2,500	3,900
San Diego Bay	350	397	462	13	442	1,100
Totals	33,187	59,520	57,913	75,412	61,339	64,703

Pacific Coast Eelgrass Conditions, 1941-1942

Summaries of the depletion of eelgrass on the Pacific Coast and its suspected cause were provided by Moffitt and Cottam (1941), Moffitt (1941) and by Dr. C. E. Renn (1942). These reports dealt with the depletion from the time it was first noted in 1940 until the summer of 1941. Observers continued, as much as they were able, to check upon the condition of local eelgrass stands during the autumn and winter of 1941 and in the spring of 1942. Due to the war, however, little information has been secured since the last brant census was taken in February, 1942.

The conclusion that the writer has reached from study of these reports, from personal investigations in Tomales Bay, California, last winter, and from the results, mentioned beyond, of Dr. Renn's examinations of Oregon and California eelgrass samples, is that the disease, *Labyrinthula*, must be present in a mild form more or less all along the Pacific Coast. Reports of the abundance and appearance of eelgrass in several California bays in February, 1942, indicated in most cases improvement had been made over the previous year. Yet in some instances both the appearance of the eelgrass and Dr. Renn's examinations of samples collected from the same localities, indicated that *Labyrinthula* was still present. It seems that either the type of *Labyrinthula* infecting the Pacific Coast eelgrass is a milder form than that which almost completely destroyed the plant on the Atlantic Coast about 10 years ago; or that the strain or variety of eelgrass inhabiting our waters is much more resistant to this organism.

Inspection of eelgrass plants in Humboldt Bay by Warden Werder in February, 1942, indicated that normal conditions obtained. Dr. Renn examined samples collected in South Humboldt Bay on February 10, 1942, for *Labyrinthula*, and reported negative results. The behavior of brant in Humboldt Bay last Winter and this Spring indicated considerable increase in the quantity of eelgrass since the previous year. On April 25, 1942, John M. Davis of Eureka wrote that while brant were late to arrive at Humboldt Bay the previous winter, normal numbers seemed to be present by March. Up to April, he stated, he had not observed a single brant feeding in the fresh-water fields, where the year before they were frequently noted after midwinter. These observations indicate that sufficient natural food, eelgrass, was present in Humboldt Bay last Winter to support the number of brant present.

Warden Laws collected samples of eelgrass in Bodega Bay on February 10, 1942, which Dr. Renn later examined and found to be infected by *Labyrinthula*. Laws noted little or no improvement in the local eelgrass stands over the previous year. It seems that the reduced quantity of the plant in this bay may be responsible for the small number of brant recorded by the census.

The writer visited Tomales Bay on September 22, 1941, for the purpose of inspecting the eelgrass and collecting samples of it. The same area was covered in which on July 16, 1941, Cottam and Moffitt (1941) had found plants showing the characteristic appearances of *Labyrinthula* infection. In September, however, careful search failed to reveal a single plant with any indication that *Labyrinthula* was present. Furthermore, samples collected at that time and later examined microscopically failed to indicate presence of the disease. All of

the eelgrass observed in September appeared to be healthy and the luxurious growths encountered indicated much improvement over the July visit. The new leaves of the 1941 season were in most cases as large as the older ones and were bright green and healthy in appearance. No wind-rows of eelgrass were observed washed up on the beaches of Tomales Bay on this date, or upon several visits to the bay in November and December, 1941.

On a visit to Tomales Bay on November 3, 1941, H. J. Jensen of Hamlet, reported having that morning observed the first brant noted by him on the bay that autumn, a small flock south of Hog Island. The writer found the birds fairly plentiful, 1,500 being estimated present, on November 20th. By November 30th, there were easily 3,000 brant present and a similar number was noted December 6th and 7th. At all times that these brant were observed, their behavior seemed to be normal. Normal flights were made from the ocean to the bay for feeding and at no time were the birds found feeding in unusual situations such as were so commonly reported for this region during the previous season. These observations strengthened the conclusion that local eelgrass conditions had improved materially.

D. A. Simpson, California Academy of Sciences, kindly collected samples of eelgrass from Tomales Bay near Nick's Cove, on March 8, 1942. These were later examined by Dr. Renn for presence of *Labyrinthula* with negative results, a further indication of improvement of eelgrass conditions locally.

Warden Yates collected samples of eelgrass in Limantour, a branch of Drake's Bay, on March 11, 1942. These were later found to show positive presence of *Labyrinthula* when examined by Dr. Renn, and also in an examination made at the California Academy of Sciences by Dr. J. Goodman. This indicated definitely that the disease was still present in this area.

Warden Hecker, when taking the brant census at Morro Bay, February 10, 1942, also observed and collected samples of eelgrass. He reported no apparent decrease in the area of eelgrass as compared with that of the previous year. The beds of the plant, however, were on that date found to be closely eaten down by the brant and many of the plants' leaves were observed to be discolored and covered with brown blotches characteristic of *Labyrinthula* infection. Samples collected at that time were later found by Dr. Renn to show positive presence of the disease, thus fully bearing out Hecker's conclusions. In spite of the continued presence of the disease in the Morro Bay eelgrass and the large numbers of brant recorded there by the census, Hecker reported that at no time during the winter were the birds seen feeding upon *Salicornia*, as they did extensively a year previously. This observation, plus the fact reported previously that no brant were this year found feeding along the coast in this area, seems to indicate that in spite of continuation of the disease, sufficient eelgrass remained in Morro Bay to feed the large number of brant that wintered there.

Warden Bedwell reported that since the construction of a drainage canal from the upper end of the lagoon at Point Mugu to the Hueneme area, there has been a large amount of silt deposited in the lagoon which buried much of the eelgrass in the area north of the bridge across

the lagoon. At the time of the 1942 census, however, eelgrass was observed by Bedwell to be growing up through the silt, so that normal conditions may be reestablished, provided that further large deposits of silt do not occur. Bedwell further advised that at no time were eelgrass stands at the extreme south end of the bay affected by the silt and that at the time of the census, there was sufficient eelgrass for the small number of birds found present. Samples of eelgrass collected by Bedwell on February 16, 1942, for Dr. Renn, were found by the latter not to be affected by *Labyrinthula.*

Warden Glidden made observations of eelgrass conditions and collected samples in Mission Bay on February 10, 1942, and again in mid-March. He reported that the plant was plentiful in this bay where larger growths of apparently healthy eelgrass were found than in previous years. Samples were taken from two localities in Mission Bay and examined by Dr. Renn who found *Labyrinthula* positively present in one of them and not in the other. Since *Labyrinthula* was also found in samples collected by Glidden in 1941, the disease has apparently been present locally for at least several months with little or no visible deleterious effect upon the plant's abundance. It will be interesting to watch the future developments in this area to see if the disease has so recently reached the locality as not yet to have caused depletion, or whether some other factor is responsible, such as specialized local conditions, or a less susceptible strain of eelgrass along the southern part of the Pacific Coast.

In the spring of 1942, as in 1941, Glidden was unable to find any eelgrass in San Diego Bay where the plant appears to have been completely killed out by some cause. In spite of this fact, the largest number of brant reported in any of the 12 annual censuses was recorded in 1942. In reporting this fact, Glidden commented that he wondered upon what the brant of San Diego Bay subsisted. He stated that this population and that of Mission Bay do not appear to exchange positions and that the birds of San Diego Bay seem to remain there for a considerable time. The writer believes that the brant of San Diego Bay may subsist to a large extent upon sea lettuce (*Ulva lactuca*), great quantities of which plant he noted along the western shore of San Diego Bay in October, 1942.

In addition to examining for *Labyrinthula* samples of eelgrass from the above mentioned California localities, Dr. Renn was also able to examine material from several localities in Oregon through the much appreciated cooperation of S. G. Jewett, U. S. Fish and Wildlife Service, Portland, Oregon. Jewett collected samples from the six Oregon localities mentioned in the table below, which recapitulates Dr. Renn's reports on material from the Pacific Coast.

The writer wishes to take this opportunity to express his sincere appreciation of Dr. Renn's kindness in studying this material, and for his permission to make the results known in this paper. His continued interest in our Pacific Coast eelgrass problems is most valuable. In the following table, Dr. Renn advises, "positive" simply means that he found *Labyrinthula* definitely present in the samples, while "negative" means that he did not find it. It is quite possible that other samples of eelgrass from localities whence Dr. Renn did not observe

the organism in the material, might indicate its presence; but for the moment, it is assumed that his negative observations indicate relative freedom from the disease.

TABLE 2

Report on presence of *Labyrinthula* in samples of *Zostera marina* collected in California and Oregon in 1942, examined by Dr. C. E. Renn of Harvard University, May 14, 1942

Sample Collected	*Collected by*	*Date Collected*
Positive Samples		
Netarts Bay, Oregon	S. G. Jewett	3/ 9/42
Coos Bay, Oregon	S. G. Jewett	3/10/42
Yaquina Bay, Oregon	S. G. Jewett	3/ 9/42
Bodega Bay, California	Bert Laws	2/10/42
Limantour Bay, California	R. J. Yates	3/11/42
Morro Bay, California	F. W. Hecker	2/10/42
Mission Bay No. 2, California	E. H. Glidden	2/16/42
Negative Samples		
Nehalem Bay, Oregon	S. G. Jewett	3/ 8/42
Siletz Bay, Oregon	S. G. Jewett	3/ 9/42
Tillamook Bay, Oregon	S. G. Jewett	3 /42
South Humboldt Bay, California	L. Werder	2/10/42
Tomales Bay, California	D. A. Simpson	3/ 8/42
Point Mugu Lagoon, California	R. E. Bedwell	2/16/42
Mission Bay No. 1, California	E. H. Glidden	2/16/42

Summary

In point of total numbers, the 1942 census of black brant in California compared favorably with results of 11 previous censuses, even though no count was obtained this year from Drake's Bay to include in the total. In 1942, 64,703 brant were counted in six localities. A year previous, 61,339 birds were recorded from the same areas, while the ten year average from all localities, including Drake's Bay, prior to 1942 was 57,344 brant.

Humboldt, our most important brant bay, showed better than average numbers present this year with a slight decline over the previous season. The next to the smallest of 11 censuses was reported from Bodega Bay in 1942. The Tomales total of 2,370 brant this February was less than half of the previous 11-year average for this locality, yet substantial improvement was evidenced over the all-time low count of 1,540 brant in 1941. For the second successive year no census was available from Drake's Bay. In 1942, Morro Bay yielded a much larger than average total of 8,861 brant. This count has only once been exceeded, in 1939 when 11,140 brant were reported, and is substantially in excess of the average of 5,964 brant for the 10 former Morro Bay censuses, even in spite of reports of continued eelgrass depletion from the area. The unprecedentedly large numbers of brant reported in 1942 from both Mission and San Diego bays, where respectively 3,900 and 1,100 birds were censused, was one of the gratifying features of this year's results. The brant have increased in this area during the period that the censuses have been taken, from none in 1932 to the present high.

Studies of eelgrass areas in California during the past winter and spring indicate that the depleted condition first apparent in 1940, and last year reported as becoming serious to brant in some of the bays, had undergone general improvement by the spring of 1942. Most California localities reported greater abundance of the plant than in the previous year and more normal behavior of the brant, a probable result of this increase in their favorite food. In some localities, notably Bodega Bay, eelgrass conditions were still poor. Presence of the disease was observed in the eelgrass of Morro Bay and further substantiated by examination of samples from the area, yet almost record numbers of brant were recorded from the locality, where their behavior was observed to be quite normal. In spite of *Labyrinthula* being found in a sample of eelgrass collected in Mission Bay in March, 1942, the most luxuriant local growths of this plant in several years were observed, together with a record number of brant.

The above results make it difficult, with the information at hand, to reconcile brant abundance with eelgrass depletion, also to predict the course of the present infection of our eelgrass by *Labyrinthula*. It is certain that the disease is present in many of our bays and also in several bays in Oregon, but the effect of the organism upon Pacific Coast eelgrass appears to be mild indeed when compared to the disastrous results wrought upon stands of the plant on the Atlantic Coast ten years ago.

It is hoped that even during the present war period local observers, bearing in mind the possible critical effects of further eelgrass depletion upon the brant, may have opportunity to make occasional observations on both plants and birds.

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THE EFFECT OF MINING SILT ON YIELD OF FRY FROM SALMON SPAWNING BEDS[1]

By Paul A. Shaw and John A. Maga, *Pollution Detail, California Division of Fish and Game*

Introduction

The silting of stream beds from mine tailings has long been regarded as deleterious to the development of salmon spawn, but little data have been available to show the extent of this damage. Ellis (1937), a recognized authority on stream pollution, states that "erosion silt and other suspensoids affect fisheries directly by covering the bottom of the stream with a blanket of material which kills out the bottom fauna, greatly reduces the available food, and covers nests and spawning grounds * * *." On the other hand, a study sponsored by the Oregon State Department of Geology and Mineral Industries (Ward, 1937-1938) asserts that mining activity was not found to be damaging to fish life on the Rogue River. This latter publication has been extensively quoted in California to combat control measures advocated by recreational groups and the Division of Fish and Game in the interest of clean streams and conservation of aquatic life.

In view of the extensive mining activity along trout streams and within watersheds that are essential to the maintenance of California salmon and steelhead, an experimental study was conducted to aid in settling the existing controversy and establish a factual basis for adequate but just enforcement action.

The experiments were conducted between January 7th and April 15, 1941, at the Brookdale Fish Hatchery, Santa Cruz County, California, and were planned in a manner to determine the yield of fry from salmon eggs in gravel nests subjected to mining silt as compared to the yield from similar nests without silt additions.

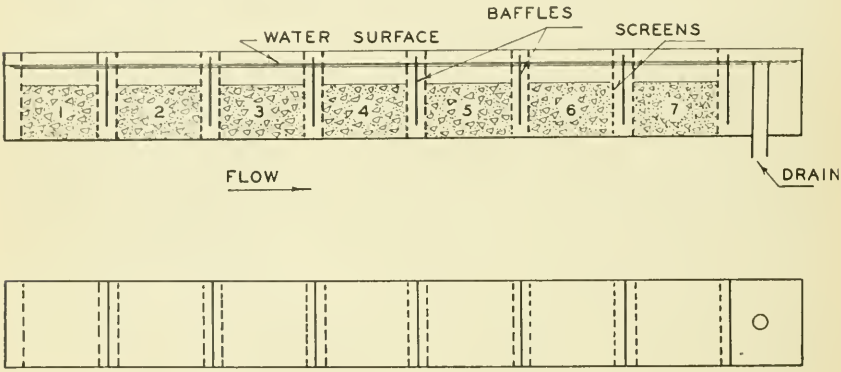
While the authors planned and supervised the investigations here recorded, they are greatly indebted to the late James L. Stinnett, hatchery foreman, and James Hinze, fish hatchery assistant, for aid in all phases of the work. These men handled the spawning operations, conducted a basket hatch control, and carried out the daily work of adding silt, adjusting water flows, recording temperatures, and collecting and counting fry as they emerged from each gravel nest. Leo Shapovalov, senior fisheries biologist, supervised the handling, counting and placing of the fertilized eggs in the gravel beds. Warden Donald Hall, of the Pollution Detail, located the site for collection of the mining silt, and personnel from the Central Valleys Hatchery transported the necessary amount from the Cosumnes River watershed to the Brookdale Hatchery.

[1] Submitted for publication October, 1942.

Experimental Procedure

Construction of Gravel Beds

Three standard hatchery troughs were each divided into seven nests 16″ wide and 20″ long by installing ¼″ wire screens on the upstream side and ⅛″ wire screens on the downstream side. A space of 4″ was left between nests. The finer mesh prevented loss of gravel or passage of fish to adjacent nests while the larger mesh permitted access of the emerging fry to the upstream space between nests where they could be caught and counted more readily. Baffles were placed between nests to force the water downward through the nests and prevent short circuiting above the gravel. Figure 11 shows a cross section of one trough to illustrate the arrangement more clearly. Gravel which had been secured from the San Lorenzo River bottom and freed of silt by washing on an ordinary window screen was placed in the 21 nests to a depth of one to two inches.



LONGITUDINAL SECTION & PLAN SHOWING GRAVEL BED ARRANGEMENT OF ONE TROUGH

FIG. 11

Spawning

A total of 37,700 silver salmon eggs (*Oncorhynchus kisutch*) measuring 198 per ounce were taken from 17 females at the San Lorenzo egg collecting station on January 7, 1941. The eggs were fertilized in the usual manner and covered with water in a 10-gallon fish planting can where they were allowed to harden for one hour before transportation to the hatchery.

Distribution of Eggs

The eggs were thoroughly mixed so that each experimental group would be uniform in character. Groups of 500 eggs were then counted and placed on the gravel in each of the 21 nests. The eggs were then covered by three to four inches of similar gravel and the trough drains arranged to maintain one to two inches of water above this level. In a

fourth trough 13,600 additional eggs were placed in each of two standard hatching baskets for determining the time of hatch and yield of fry under the usual hatchery procedure.

Addition of Mining Silt

The seven nests of Trough 1 received only the hatchery supply of water without addition of mining silt and served as a control for determining the yield of fry from salmon eggs in unsilted gravel beds, and also provided a comparison with the normal basket hatch.

For producing turbidity in the 14 nests of Troughs 2 and 3, wet mining silt was secured from the settling ponds of the Pacific Placers Engineering Company on Arkansas Creek, a tributary of the Cosumnes River. This material was typical of the fine silt and slimes discharged by gold dredging operations in many California mining areas. Figure 12 is a photograph showing the crew collecting this material.

FIG. 12. Crew collecting mining silt for experiment.

Two to three buckets of the wet slimes were agitated in a barrel of water by means of a recirculating pump and the addition of a small stream of water from the hatchery supply produced a muddy overflow which was led to the desired point of application by a small wooden flume installed between experimental Troughs 2 and 3. Fed in the manner described, the above quantity of silt lasted 2 to 4 hours after which the experimental nests received only hatchery water until the following day.

The silt laden water from the flume was introduced at the desired nest by boring $\frac{3}{4}''$ holes in the side of the flume. Outlets not in use were plugged with rubber stoppers. The muddy water was always added between nests and above the baffle board in order to cause mixing with the hatchery water before reaching the adjacent gravel nest.

In Trough 2 the turbid water was started above the first nest on January 7th, the initial day of the experiment. Entering at this point,

the flow of water carried silt to all seven nests of the trough. During the course of the experiment the point of silt application was changed to gravel nests further downstream, thus producing turbidity in the lower nests for progressively longer periods, while the upper nests received silt only for the earlier stages of the incubation period.

The above procedure was reversed for Trough 3 in which silt was first applied to nest 7 and was progressively changed to upstream points as the period of incubation advanced. Silting was discontinued on March 20th. Thus the upper three nests did not receive silt during incubation but were subjected to silt for varying portions of the early emergence period. The four lower nests received silt during the first half of the emergence period and also were silted for progressively longer portions of the incubation period, nest 7 receiving silt from the initial day of the experiment. The period of silt addition for Troughs 2 and 3 may be visualized by referring to Figures 15 or 17.

Analyses and Records

Records were kept of water temperature, volume of flow, dissolved oxygen, pH, and suspended solids. Analyses will be found in Tables 4 and 5. In summary, the water temperature varied from 48° to 54° F.; dissolved oxygen from 10.0 to 11.8 p.p.m., and pH from 7.4 to 7.6. No appreciable difference in oxygen content was found above and below the gravel nests. The water flow in the trough containing the basket hatch was maintained at approximately 18 gallons per minute, while the flow in the three gravel bed troughs was approximately 8 gallons per minute.

Seven analyses of the suspended solids content of overflow water below the lowest nests of Troughs 2 and 3 showed an average of 1176 p.p.m. (Table 5). At the same time values for points 1-3 nests upstream showed an average of 1330 p.p.m. The average loss per nest was 83 p.p.m. While this may appear to be a high rate of deposition it should be remembered that silting was limited to 2-4 hours daily and that a gradual decrease occurred during this period from the above amount to clear hatchery water.

As fry began to appear above the gravel they were collected, counted and preserved with formaldehyde in bottles numbered to correspond to the different nests. After one hundred days, when no further fry appeared, the gravel was carefully removed from each nest in order to count and observe the condition of eggs and fry that remained in the beds.

Experimental Results

Yield of Fry—Basket Control

The salmon eggs that were handled by baskets in flowing water according to usual hatchery procedure hatched between February 12 and 14, corresponding to an incubation period of 36-38 days. The yield was 79.9%. The temperature averaged 51.3° F. for the 38 days to maximum hatch from which it may be calculated that 733 temperature units were required.

Yield of Fry—Gravel Control Nests

The first fry appeared above the gravel in six of the control nests of Trough 1 on February 27th. Assuming that the hatch time in the gravel corresponded to the basket hatch, then 13 days elapsed to first emergence of fry above the gravel. The temperature during this period averaged 51.9° F., representing an additional 259 temperature units. In the other nest (#3) the first fry appeared on March 4. Fry emerged for 44 days, until April 11, or a total of 94 days from the start of the experiment. The seven control nests yielded an average of 16.2% and a maximum of 25.4% fry from eggs (see Table 1). At the conclusion of the experiment the entire mass of gravel from each control bed was searched and the remaining eggs and fry counted. (See Table 1.)

TABLE I

Yield and Recoveries from Gravel Control Nests
(500 Salmon Eggs per Nest)

Nest	Yield of Fry		Fry and Eggs Recovered from Gravel	
	Number of Fry	Per Cent Yield	Number of Fry	Number of Eggs
1	30	6.0	36	4
2	8	1.6	3	4
3	64	12.8	5	9
4	127	25.4	24	1
5	106	21.2	12	11
6	111	22.2	7	14
7	120	24.0	35	3
Total	566		122	46
Average	81	16.2	17	7

During the incubation period several storms brought in natural sediment which tended to settle in the upper nests of the trough. Samples taken during one storm contained 50 p.p.m. of suspended solids above nest 1 and 33 p.p.m. below nest 7, indicating a deposition of 17 p.p.m. Visual observation indicated that most of this sediment, which was very dark in color, settled on the first three nests while the last four were relatively free from silt. The higher and fairly constant yield of live fry from the last four nests is therefore representative of development without appreciable silting, while the lower values from nests 1-3 represent yield of fry for gravel beds that were subject to natural silting. Previous experiments by Shapovalov (1937) on development of steelhead eggs in artificial gravel nests resulted in a yield of 29.8% during a period of storms and a yield of 79.9% in tests at a later date when storms were not prevalent. Further experiments by the same author (Shapovalov and Berrian, 1939) on development of salmon eggs in gravel resulted in the low yield of 10.2% which was attributed to silting from severe storms.

The rate of appearance above the gravel is of considerable interest and is shown in Figure 13 as the total number of fry for all seven control nests with respect to the time of emergence. The peak emergence, as shown by the slope of the curve, occurred 20-22 days after appearance of the first fry. The rate then decreased until the last fish appeared on the forty-fourth day. Table 6 includes the date and number of fish appearing from all control nests.

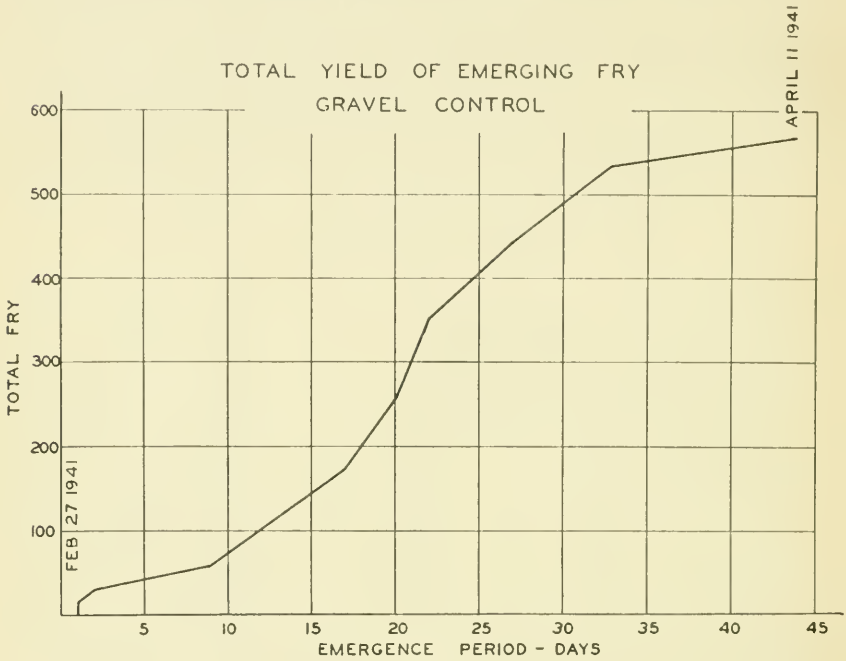


Fig. 13

In no case was the recovery of live fry plus fry and eggs in the gravel greater than 158 out of 500 originally placed in each nest. The recovery of relatively few eggs therefore indicates that undeveloped ones had decomposed and disappeared, as would be expected. The number of fry that hatched but died without working up through the gravel was relatively small.

Yield of Fry—Early Silt Addition

Table 2 shows the essential data for the seven nests of Trough 2 which received mining silt for varying time periods from the beginning of the experiment. The yield of fry from nest 7 is not included since this nest was dug into and the deposited silt flushed off on March 9th, when it was thought no fry were going to emerge from this series.

The average yield of 1.16% fry from this series is so low that comparisons between nests do not appear warranted. The outstanding fact is that silt added during the initial stages of incubation and continued for either a few days or a longer period, causes severe damage resulting in low yields of fry. The emergence of fry above the gravel

is also retarded, as a period of 19 days totalling 393 temperature units elapsed between the first appearance in the gravel controls and this series. The last fry emerged on April 15th. In general these fry were smaller and weaker than those of the control series and a number of deformities were noted.

TABLE 2

Effect of Mining Silt During Early Stages of Incubation—Trough 2

Nest	Date silt addition, 1941	Time silt addition (days)*	Date first fry appeared	Yield of fry		Recovered from gravel	
				Number	Per cent	Fry	Eggs
1	1/7–1/ 9	2	3/18	12	2.4	3	41
2	1/7–1/14	7	3/31	4	0.8	4	49
3	1/7–1/21	14	3/25	5	1.0	10	61
4	1/7–2/ 4	28	3/31	1	0.2	0	98
5	1/7–2/18	42	4/ 7	1	0.2	10	24
6	1/7–2/26	50	3/18	11	2.2	16	6
7	1/7–3/20	72				17	5
			Average	5.8	1.16		

*2-4 hours daily.

The larger number of whole eggs remaining in the gravel at the conclusion of this experiment is significant as it shows a tendency for undeveloped eggs to resist decomposition apparently due to a protective coating of silt. The number of fry remaining in the gravel was small but totaled more than the fry that emerged and may therefore indicate difficulty in working through the deposited silt.

A comparison of the fry from the control nests and this series as shown in the photograph, Figure 14, reveals the striking reduction in yield from mining silt. As previously explained, the fry from nest 7, series 2 should be disregarded.

SERIES I. Control—No Silting

1 2 3 4 5 6 7

SERIES II. Mine Silt Added

FIG. 14. Showing the marked difference in yield between the Control, Series I, and Series II, with early silt addition.

Yield of Fry—Late Silt Addition

The yield of fry and the number of eggs recovered from the nests of Trough 3 follow a definite, consistent pattern and are of particular interest and significance. Table 3 shows the data for this series which

received silt for varying periods of the latter portion of the incubation and emergence time.

TABLE 3

Effect of Mining Silt During Later Stages of Incubation and Emergence—Trough 3

Nest	Date silt addition, 1941	Time silt addition* (days)	Date first fry appeared	Yield of fry		Number recovered from gravel	
				Number	Per cent	Fry	Eggs
1	3/5–3/19	15	----------	----------	----------	4	10
2	2/26–3/19	22	2/28	67	13.4	2	10
3	2/18–3/19	30	3/4	42	8.4	1	12
4	2/11–3/19	37	2/28	38	7.6	0	15
5	2/4–3/19	44	3/16	8	1.6	1	39
6	1/21–3/19	58	3/4	4	0.8	0	90
7	1/7–3/19	72	----------	0	0.0	6	145

*2-4 hours daily.

In the first nest of this series only the first fry was removed, after which the others were allowed to remain in the water above the nest, as it was desired to determine the effect of turbid water on the fry. Unfortunately these fish were lost during a flood on the last day of the experiment and a count was not obtained.

The six nests of Trough 3 on which complete data were secured show a fair yield of fry when silt additions occurred only after the normal basket hatch period (nests 2 and 3). The yield steadily decreased for earlier initial dates of silt addition and nest 7, which received silt from the day the eggs were first placed in the gravel, yielded no fry. This series confirms series 2, that silt addition during the incubation period causes severe damage and indicates that silting during the last week of incubation (nest 5) may reduce the yield as much as silting during the first week, and almost as much as silting for the entire incubation period. Silting after the hatch date, but during the period the fry are working up through the gravel may reduce the yield, but the damage is not so extensive.

The eggs recovered from these nests at the conclusion of the experiment show steadily increasing numbers for earlier dates of silt addition corresponding to decreased yield of fry and further show that silt forms a coating which preserves the egg and prevents development of the fry. These eggs had faded in color but were not white and the coating with fine particles from the mine slimes was obvious. Figure 15 is a photograph showing this series of fry and eggs. As previously explained, the single fry shown for nest one should be disregarded as a total count was not obtained.

The number of fry recovered from the gravel of Trough 3 was small, apparently indicating egg damage rather than inability of the fry to work through the gravel and silt. In this connection it was observed that most fry appeared to emerge by coming through the $\frac{1}{4}''$ screen into the space between nests rather than working directly upward through the deposited silt. For this reason the yields might have been still lower if finer screens had been installed on the upstream side of the gravel nests. For the total of 196 fry recovered at the conclusion of the experiment from the gravel of all 21 nests, only five

were found to be alive. In general these fry were small, poorly developed or deformed.

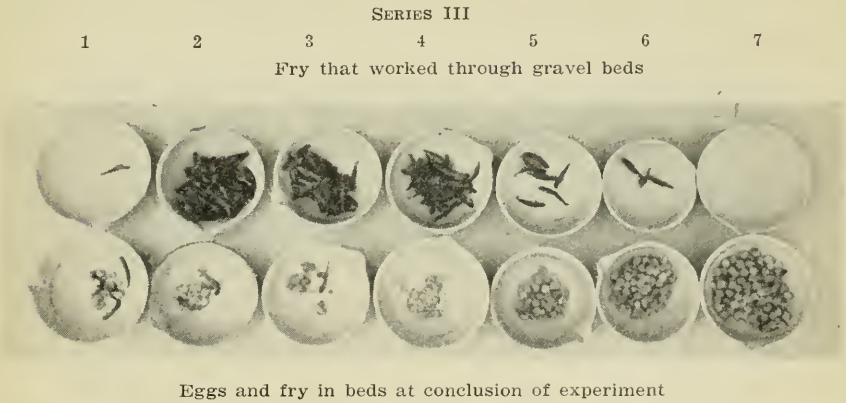


FIG. 15. Showing the relation between emerging fry and silt-coated eggs remaining in the gravel of Series III. Fry in Bed 1 should be disregarded as explained in text.

The effect of silting on yield is strikingly revealed in Figure 16 which is a composite photograph showing fry that emerged from the gravel controls and all the silted nests combined with charts showing incubation, emergence and silt periods. In this connection it should be noted that the horizontal line for first emergence applies to the gravel control rather than the silted nests.

Figure 17 shows graphically the normal time of basket hatch in relation to period of emergence, time of silt additions, and yield of live fry for the 19 gravel nests on which full data were secured.

Summary, Conclusions and Recommendations

1. Salmon eggs hatched in the usual manner by placing a basket of eggs in the flowing water of a hatchery trough produced a yield of 79.9% fry with 733 temperature units.

2. Salmon eggs placed in prepared gravel beds constructed in a hatchery trough and receiving only normal hatchery water produced a maximum yield of 25.4% and an average yield of 16.2% fry. Occasional silting of the water supply due to storms may have lowered the yield. To first emergence from the gravel 992 temperature units were required.

3. Salmon eggs in prepared gravel beds that received mining silt for intervals of 2 to 72 days beginning with the initial stages of incubation produced a maximum yield of 2.4% and an average yield of only 1.16% fry. A total of 1385 temperature units were required to first emergence from the gravel. Many of the undeveloped eggs remaining in the gravel were preserved with a coating of silt. Fry that died or failed to emerge outnumbered those that worked through the gravel.

4. Salmon eggs in prepared gravel beds that only received mining silt during the emergence period produced a yield of 13.4% fry but

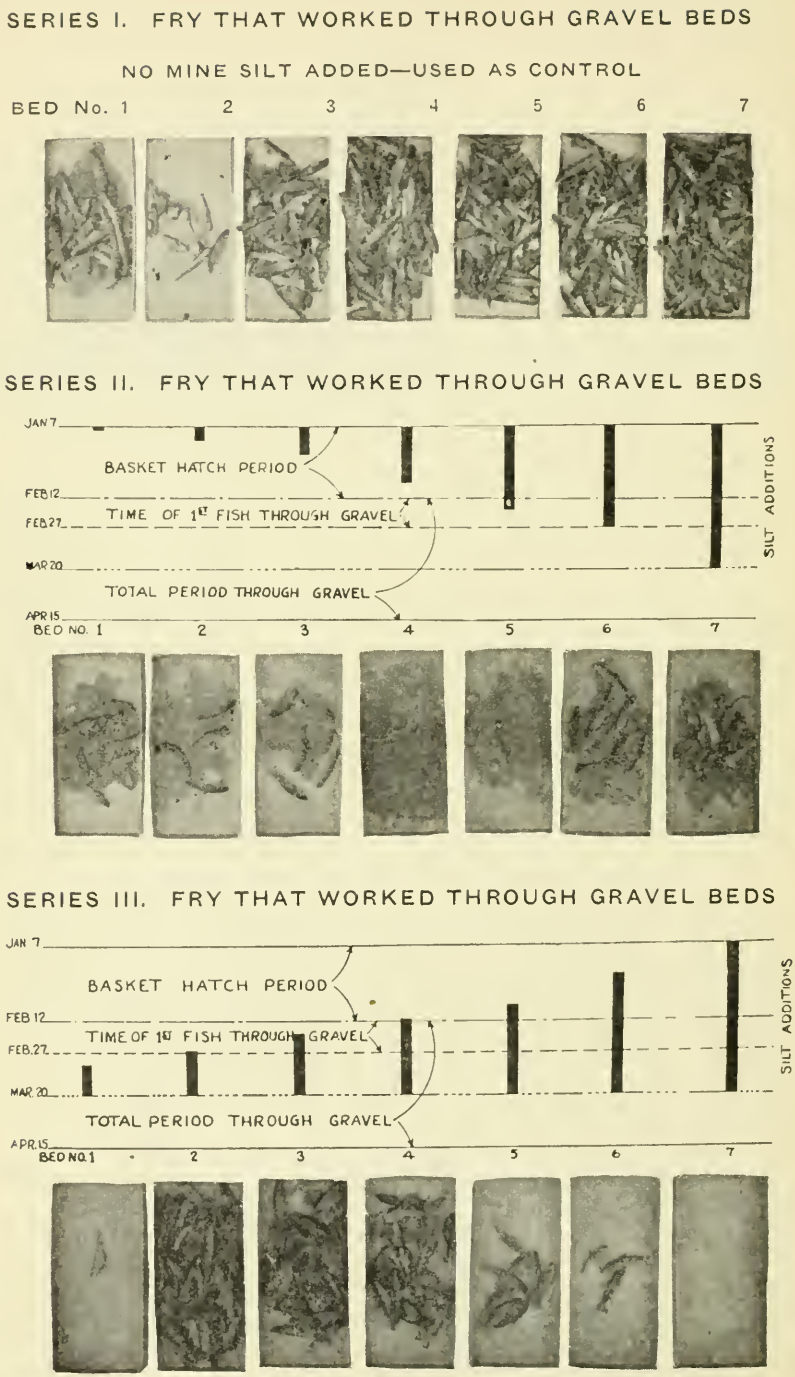


FIG. 16. A composite photograph showing the fry that emerged from the 7 control nests and the 14 silted nests in relation to the silting period. As explained in the text, Nest 7, Series II and Nest I, Series III, should be disregarded.

earlier silt additions extending back into the incubation period produced progressively lower yields which reached zero with silting at the beginning of the incubation period. In this series the number of undeveloped eggs that were coated and preserved with silt increased steadily with earlier and longer periods of silt addition. Very few fish that hatched failed to emerge but many fry apparently worked forward through a screen rather than upward through the gravel and deposited silt.

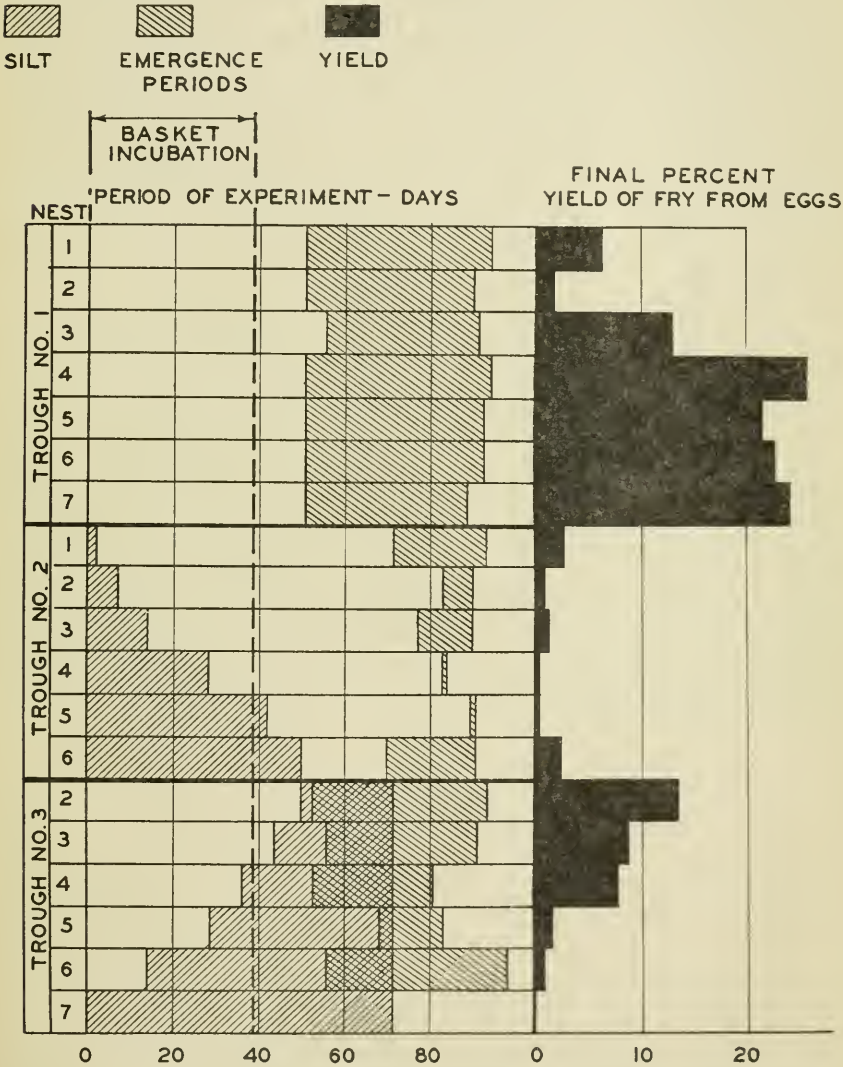


FIG. 17. Graphic summary showing 19 nests of the experiment, with days to emergence of first fry, total emergence periods, and yield from each nest of unsilted gravels (Trough 1) and silted gravels (Troughs 2 and 3) as compared with hatching time of 36-38 days in hatchery baskets ("Basket Incubation") which yielded 79.9% fry. Delayed emergence and decreased yields are particularly evident for Trough 2, with early silt additions.

From the data presented in this paper it is evident that the yield of fry from eggs hatched in gravel beds supplied with normal hatchery water is far below that attained by the usual procedure of basket hatching in flowing water. The experiments further show that mine silt deposited on gravel spawning beds during either the early or later stages of incubation results in negligible yields of fry and is therefore a serious menace to natural propagation.

From a practical standpoint this damage to spawning beds would occur when mining silt enters a stream at times other than storm periods when the water velocity is insufficient to carry the sediment in suspension. It is a well known fact that the velocities necessary to dislodge deposited particles are far greater than the velocities required to carry the same particles in suspension. For this reason natural stream turbidity is largely limited to those periods when storm water causes erosion. During these periods stream flows in areas suitable for steelhead, trout, or salmon spawning are sufficient to prevent bottom deposits of natural erosion silt and damage to eggs in the gravel is minimized. Thus, while mining silt may be natural material, its presence in waterways during nonerosion periods results in bottom deposition which is unnatural and damaging.

From the data presented it is apparent that adequate control to prevent the discharge of mining silt where spawning grounds may be affected is essential to the preservation of normal fish populations, and legislation to secure the necessary protection is therefore recommended. This recommendation applies only to protection of spawning grounds, as the studies did not include the effect of suspended silt on fry after emergence above the gravel. However, irrespective of whether fry and adult fish are injured by silt in suspension, the damage to domestic, agricultural, industrial and recreational water uses from high turbidity is sufficient to justify a reasonable but adequate control. To secure such control, not only on mining but on pollution from varied sources, the authors suggest that a state agency with authority to act with respect to all water values and uses above mentioned would be desirable. In this way the public could be assured of proper action on complaints and violations rather than being referred from agency to agency having different jurisdictions, as now happens.

TABLE 4

Water Analyses

Date, 1941	Temp., F.	pH	Dissolved oxygen P.P.M.							
			Basket		Control		Trough 2		Trough 3	
			Above	Below	Above Nest 1	Below Nest 7	Above Nest 1	Below Nest 2	Above Nest 1	Below Nest 7
1/ 9	53½°	7.6	11.6	11.6	11.3	11.3	11.4	11.5	11.8	11.8
1/13	51	7.5	11.6	11.6	11.8	11.7	11.8	11.8	11.6	11.6
1/21	51	7.6	11.4	11.4	11.1	11.0	11.3	11.4	11.3	11.4
2/4	51	7.6	11.2	11.2	11.3	11.3	11.3	--------	11.4	--------
2/11	52½	7.5	11.0	10.9	10.9	11.0	11.0	11.1	10.9	11.0
2/18	53½	7.5	11.2	11.2	11.2	11.2	11.2	11.1	11.1	11.2
3/31	53	7.4	--------	--------	10.0	--------	10.2	10.3	10.1	--------

TABLE 5

Suspended Solids

Date, 1941	Sample point	P.P.M.	Sample point	P.P.M.	Number of intervening beds
1/15	Trough 2, Bed 4	1500	Trough 2, Bed 7	1200	3
1/21	Trough 2, Bed 5	860	Trough 2, Bed 7	896	2
2/4	Trough 2, Bed 5	2020	Trough 2, Bed 7	1760	2
2/18	Trough 2, Bed 6	1100	Trough 2, Bed 7	1100	1
1/21	Trough 3, Bed 6	1170	Trough 3, Bed 7	1040	1
2/4	Trough 3, Bed 5	1460	Trough 3, Bed 7	1060	2
2/18	Trough 3, Bed 5	1200	Trough 3, Bed 7	1180	2
	Average	1330		1176	1.86

Deposit per bed $= \frac{1330-1176}{1.86} = 83$ p.p.m.

TABLE 6

Gravel Control Nests

Date, 1941	Number fry emerging								
	Nest							Total	
	1	2	3	4	5	6	7	Daily	To date
2/27	1	1		2	5	3	1	13	13
2/28		1		3	3	4	7	18	31
3/1		1					2	3	34
3/2				1	1			2	36
3/4		1	4	2		2		9	45
3/5						1	1	2	47
3/6			1			5	3	9	56
3/7				1	1	1		3	59
3/9			6	2	3	11	4	26	85
3/10		1	4	4	4	7		20	105
3/12			1	2	1	3	4	11	116
3/13				9	2	5	4	20	136
3/15			2	15	7	5	6	35	171
3/16	3		4	6	5	7	5	30	201
3/18	5		2	31	11	1	3	53	254
3/20	7		9	19	24	12	27	98	352
3/25	8	1	15	10	13	16	25	88	440
3/28	3		8	10	7	10	15	53	493
3/30	1		3	5	7	7	3	26	519
3/31	1		1		3	5	7	17	536
4/4			1	2	2	1	3	9	545
4/7		2		1	3	2		8	553
4/8			3	1	2	1		7	560
4/9					2	2		4	564
4/11	1			1				2	566
Total	30	8	64	127	106	111	120	566	

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EDITORIALS AND NOTES

SPECIAL REGULATIONS AFFECTING THE 1942 DEER SEASON

The hunting of deer in California in 1942 has been subjected to various special regulations, all related to the war. Their history is set forth below.

On June 1st, 1942, Regional Office No. 5 of the U. S. Forest Service closed the Los Padres, Angeles, San Bernardino and Cleveland National forests against trespassing because of intensification of the fire hazard due to lack of fire-suppression personnel and equipment. This effectually closed these areas to deer hunters.

The Monterey Cattlemen's Association took the view that their private range lands, to which the hunters were likely to turn, were highly inflammable, and difficult to police because of labor shortage. They therefore asked Lieutenant General John L. DeWitt, Commanding Officer, Western Defense Command, that steps be taken to have these lands closed also. General DeWitt, basing his request on "military necessity," applied to Governor Olson to have deer hunting prohibited wherever fire hazards were found to exist.

This matter was referred to the Division of Fish and Game, and on July 27th its representatives met with the Committee on Forest Fire Prevention of the California Office of Civilian Defense. At this meeting a resolution was passed recommending the immediate closure to deer hunting of all open areas from the northern boundary of Monterey County south to the Mexican border. On July 29th the Fish and Game Commission took cognizance of the fact that a request from a commanding officer in time of war is tantamount to an order, and in view of the military necessity recommended to the Director of Natural Resources that all of San Benito and Monterey counties, and those portions of Merced, Fresno and Kings counties in District 3 be closed to deer hunting; also Fish and Game Districts $3\frac{1}{2}$, 4, $4\frac{1}{8}$, and $4\frac{3}{4}$, including the counties of San Luis Obispo, Santa Barbara, Ventura, Los Angeles, San Bernardino, Orange, Riverside, San Diego and Imperial. The approval of the Governor was given and the order was signed July 31st, but due to legal publication requirements did not become effective until August 11th.

The areas so closed failed to include all the territory envisaged, and a second request was made by the military authorities. The Fish and Game Commission thereupon held an open meeting in San Francisco on August 7th, at which legislators, representatives of State and Federal agencies, sportsmen, and other interested persons were heard. Over 35 expressed opinions, the most frequent complaint being that closure of the deer season discriminated against the hunter, while other recreationists constituting equal or greater fire hazards were unchecked. However, in view of the predominating importance of war requirements over all other considerations, the Commission recommended the closure

to deer hunting of all of Districts $1\frac{7}{8}$, 2, $2\frac{1}{4}$, $2\frac{1}{2}$, $2\frac{3}{4}$, and that portion of 3 not included in the previous order. The counties affected were Marin, Napa, Solano, Yolo, Colusa, Sonoma, Lake, Mendocino, Glenn and a small portion of Humboldt; also Contra Costa, Alameda, San Francisco, San Mateo, Santa Clara, Santa Cruz, and other parts of counties in District 3 not included in the earlier closing order.

These two closures prohibited deer hunting which normally would have been open August 1st to September 15th in Fish and Game Districts $1\frac{7}{8}$, 2, $2\frac{1}{4}$, $2\frac{1}{2}$, $2\frac{3}{4}$ and 3; from August 10 to September 9 in Districts $3\frac{1}{2}$ and $4\frac{1}{8}$; and from September 16th to October 15th in Districts 4 and $4\frac{3}{4}$.

A third request from General DeWitt caused the Commission on August 26th to recommend closure of those portions of Shasta, Tehama, Butte, Yuba, Nevada, Placer, El Dorado, Amador, Calaveras, Tuolumne, Mariposa, Madera, Fresno, Tulare and Kern counties lying below what is commonly known as the "ponderosa pine belt." This order was signed on August 31st and took effect September 16th, to close for the season an area which would otherwise have been open to hunting from September 16th to October 15th, inclusive.

To summarize: Four special regulations affected the 1942 deer season, none of which originated with the Division of Fish and Game. The first was an order of the U. S. Forest Service closing certain National Forests to all trespassers. The other three were recommendations of the Fish and Game Commission made in compliance with requests of the Commanding Officer of the Western Defense Command, which requests in turn were based on the existence of fire hazards as determined by the Committee on Forest Fire Prevention of the California Office of Civilian Defense.—*George P. Miller, Executive Officer.*

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

Leading articles in this magazine 25 years ago included an account of the skates and rays of California by Professor Starks of Stanford University, observations on bighorn sheep within 30 miles of Los Angeles by Harold Gardner, and a paper by Harold C. Bryant on the Trinity Game Refuge, the first of the large State game refuges.

But the most interesting feature of the January, 1918, number from the point of view of present-day readers is an editorial entitled "Fish and Game Endangered." This has to do with World War I, and the attempts made at that time to bring about relaxation of conservation measures on the score of emergency food needs. Such needs do exist in war time, but those who wish to supply them through abnormal capture of fish or game are not infrequently motivated by the desire for personal gain. In many cases, the added increment to the food supply is too small to be significant, while the extraordinary inroads upon the natural resources may endanger the future stock. The possible extinction of a natural resource which would otherwise be self-perpetuating should not be countenanced unless no alternative route to victory exists.

What has been the impact of the present world crisis upon California fish and game? A commercial fishing season for mullet has been

opened in the Salton Sea for the first time in over 10 years in order to increase our fresh fish supplies. In the marine commercial fisheries the catch has dropped at least 50 per cent because of wartime restrictions, withdrawal of boats from the fishing fleets, and loss of fishermen. In the sport fishery, some inland waters have been completely closed, and others closed in part, for military reasons.

Migratory birds will benefit from restrictions on the carrying of fire-arms in certain parts of the State. Dove shooting has been prohibited over large areas formerly open. Outstanding in public interest has been the complete closure of the deer season in one large section of the State, and its limitation in another, at the request of the military authorities. In some regions, deer threaten to become a serious menace to crops.

Add to the foregoing the reduction in the amount of sport fishing and hunting that will inevitably be brought about by gasoline rationing and rubber shortages, and it becomes evident that World War II, up to the present, at least, is not having a detrimental effect on California fish and game. If anything, it is tending to increase their numbers, and may build up a reserve stock which it will be the privilege of all of us—sportsmen, commercial fishermen, and conservation workers—to protect and maintain when peace returns.—*Brian Curtis, Editor, California Fish and Game.*

RETIREMENT OF J. C. LEWIS

Mr. J. C. Lewis, assistant supervisor of fish hatcheries, retired from the Division of Fish and Game on September 30, 1942, after 22 years of service. For a number of years Mr. and Mrs. Lewis made their home at Fort Seward where Mr. Lewis was in charge of the hatchery as superintendent. In January, 1934, Mr. Lewis was transferred to the Tahoe area to take charge of the two hatcheries in that important recreational portion of California. At Tahoe Mr. Lewis made an enviable record in his development of the cooperative planting program carried on jointly by the Mt. Ralston Fish Planting Club and the Division of Fish and Game.

Fortunately, Mr. and Mrs. Lewis plan to make their future home in Santa Cruz County and will thus be able to continue their close association with many friends within the Division. Their interests in the Division will also remain active because their son R. C. Lewis is foreman at the Hot Creek Hatchery, and his brother, E. S. Lewis, is an employee at the Mt. Shasta Hatchery.—*A. C. Taft, Chief, Bureau of Fish Conservation, California Division of Fish and Game.*

RETIREMENT OF HENRY LENCIONI

On September 30, 1942, Henry Lencioni, captain of patrol, completed 35 years service with the California State Division of Fish and Game.

Mr. Lencioni was appointed as a deputy in Sonoma County August 25, 1907. At that time the patrol force consisted of not over 40 deputies. In 1926 he was promoted to a captain, and served in that position until

the time of his retirement. He has witnessed many changes in the Division, from the horse and buggy days of 1907 to the present.

It is the wish of the Division that Captain Lencioni enjoy to the fullest his well earned retirement.—*L. F. Chappell, Chief of Patrol, California Division of Fish and Game.*

RETIREMENT OF J. D. DONDERO

Mr. J. D. Dondero, captain of patrol, retired from the California State Division of Fish and Game, October 30, 1942, having completed 25 years of service.

Appointed a deputy in 1917, Dondero served in that capacity until 1927 when he was advanced to a captain. He has always been headquartered in Lake and Humboldt counties, and because of his ability to make keen observations, Mr. Dondero is considered one of the best informed men on fish and game matters in that area.

It is the sincere wish of the entire Division that Captain Dondero will enjoy his well earned leave from public life.—*L. F. Chappell, Chief of Patrol, California Division of Fish and Game.*

REPORTS

FISH CASES

July, August, September, 1942

Offense	Number arrests	Fines imposed	Jail sentences (days)
Abalones: Undersized, overlimit, and out of shell	10	$180 00	
Angling: No license, closed season, closed area, within 150 ft. of dam, and not holding rod	80	876 00	10
Barracuda: Overlimit, undersized, no license	3	30 00	
Bass: Undersized, using 2 rods, after sundown, and night fishing	39	960 00	
Clams: Undersized, clam forks in preserve, and taking clams in preserve	18	340 00	
Commercial: Operating net and taking tuna in closed season, gill net in closed waters, no license, failure to give fisherman copy at delivery	12	135 00	
Crab: Undersized, closed season, and overlimit	2	25 00	
Crappie: Selling crappie	1	25 00	
Failure to show license on demand	6	65 00	5
Frog: Overlimit	1	25 00	
Gill net: Closed area	3	150 00	
Halibut: Closed season	2	100 00	
Lobster: Closed season, undersized	3	62 50	
Pollution	15	2,400 00	
Salmon: Undersized	4	100 00	
Sunfish: No license, closed season, overlimit	10	100 00	
Trout: Overlimit, closed area, not using hook and line, sale, and more than 1 pole	22	498 00	
Tuna: Closed area	2	550 00	
No party boat permit	2	25 00	
Totals	235	$6,646 50	15

GAME CASES

July, August, September, 1942

Offense	Number arrests	Fines imposed	Jail sentences (days)
Deer: Night hunting, hunting in refuge, taking forked-horn in Dist. 1¾, transfer deer tags, overlimit, closed season, killing doe, no tags, failure to have deer tag validated, taking spiked buck, taking fawn, altering deer tags	71	$2,990 00	50
Deer meat: Closed season, female	19	1,475 00	
Doves: Closed season, shooting from auto, no license	31	975 00	
Firearms: Discharging firearms in game refuge and shooting from highway	7	140 00	
Hunting: No license, failure to show license on demand, transfer of license, hunting in refuge	29	570 00	
Meadowlark	1	25 00	
Nongame birds	1	25 00	
Pigeons: Closed season	1	25 00	
Pheasants: Closed season, taking females, no license	34	1,465 00	50
Quail: Closed season, no license	13	190 00	
Rabbits: Closed season, no license	34	474 50	
Sage hens: Closed season	1	50 00	
Shooting from auto	7	210 00	
Taking wooddnck	1	25 00	
Totals	250	$8,639 50	100

SEIZURES OF FISH AND GAME

July, August, September, 1942

Fish:

Abalones	46
Abalones, red	9
Abalones, green	11
Barracuda	57
Bass, black	72
Bass, striped	14
Bass, pounds	6,077
Clams, Pismo	16
Crappie	10
Gill nets	2
Lobsters, pounds	21
Lobster traps	2
Perch	1
Sunfish	11
Trout	533
Trout, rainbow	102
Trout, pounds	1¼

Game:

Deer	12
Deer meat, pounds	516
Doves	186
Meadowlark	1
Killdeer	2
Pheasant	27
Quail	24
Rabbits, brush	14
Rabbits, cottontail	71
Rabbits, jack	2

BUREAU OF ENGINEERING

JOHN SPENCER, Chief—San Francisco
Clarence Elliger, Assistant Hydraulic Engineer—San Francisco
Samuel Kabakov, Jr., Civil Engineer—San Francisco

BUREAU OF LICENSES

H. R. DUNBAR, Chief—Sacramento
L. O'Leary, Supervising License Agent—Sacramento
R. Nickerson, Supervising License Agent—Los Angeles
Emil Dorig, License Agent—San Francisco

ACCOUNTS AND DISBURSEMENTS

D. H. BLOOD, Departmental Accounting Officer—Sacramento

BUREAU OF PATROL

E. L. MACAULAY, Chief of Patrol (absent on military leave)—San Francisco
L. F. CHAPPELL, Chief of Patrol—San Francisco

CENTRAL DISTRICT (Headquarters, Sacramento)

C. S. Bauder, Inspector in Charge—Sacramento

Northern Division

A. A. Jordan, Captain—Redding
Jos. H. Sanders, Captain—Sacramento
A. H. Willard, Captain—Rocklin
E. O. Wraith, Captain—Chico
L. E. Mercer, Warden, Butte County—Chico
Taylor London, Warden, Colusa County—Colusa
Albert Sears, Warden, El Dorado County—Placerville
E. C. Vail, Warden, Glenn County—Willows
Don Davison, Warden, Modoc County—Alturas
Earl Hiscox, Warden, Nevada County—Nevada City
Nelson Poole, Warden, Placer County—Auburn
E. J. Johnson, Warden, Plumas County—Quincy
George Shockley, Warden, Plumas County—Portola
H. S. Vary, Warden, Sacramento County—Sacramento
Charles Sibeck, Warden, Sacramento County—Sacramento
Earl Caldwell, Warden, Shasta County—Burney
Chas. Love, Warden, Shasta County—Redding
Don Chipman, Warden, Siskiyou County—Dunsmuir
Brice Hammack, Warden, Siskiyou County—Yreka
Louis Olive, Warden, Lassen County—Susanville
Fred R. Starr, Warden, Siskiyou County—Dorris
R. E. Tutt, Warden, Sierra County—Downieville
A. Granstrom, Warden, Sutter County—Yuba City
R. W. Anderson, Warden, Tchama County—Red Bluff
Harold Erwick, Warden, Tehama County—Corning
C. L. Gourley, Warden, Trinity County—Weaverville
C. O. Fisher, Warden, Yolo County—Woodland
R. A. Tinnin, Warden, Yuba County—Marysville

Southern Division

S. R. Gilloon, Captain—Fresno
John O'Connell, Captain—Stockton
R. J. Little, Warden, Amador County—Pine Grove
L. R. Garrett, Warden, Calaveras County—Murphys
F. A. Bullard, Warden, Fresno County—Reedley
Paul Kehrer, Warden, Fresno County—Fresno
Lester Arnold, Warden, Kern County—Bakersfield
C. L. Brown, Warden, Kern County—Kernville
C. S. Donham, Warden, Kern County—Taft
Ray Ellis, Warden, Kings County—Hanford
H. E. Black, Warden, Madera County—Madera
Gilbert T. Davis, Warden, Mariposa County—Mariposa
Hilton Bergstrom, Warden, Merced County—Los Banos
H. Groves, Warden, Merced County—Merced
H. J. Bullard, Warden, San Joaquin County—Tracy
Wm. Hoppe, Warden, San Joaquin County—Lodi
Geo. Magladry, Warden, Stanislaus County—Modesto
W. I. Long, Warden, Tulare County—Visalia
Roswell Welch, Warden, Tulare County—Portervlle
F. F. Johnston, Warden, Tuolumne County—Sonora

COAST DISTRICT (Headquarters, San Francisco)

Wm. J. Harp, Inspector in Charge—San Francisco

Northern Division

Scott Feland, Captain—Eureka
Ray Diamond, Warden, Del Norte County—Crescent City
Walter Gray, Warden, Humboldt County—Garberville
W. F. Kaliher, Warden, Humboldt County—Fortuna
Laurence Werder, Warden, Humboldt County—Eureka
Kenneth Langford, Warden, Lake County—Lakeport
M. F. Joy, Warden, Marin County—Tiburon
R. J. Yates, Warden, Marin County—San Rafael
Ovid Holmes, Warden, Mendocino County—Fort Bragg
Floyd Loots, Warden, Mendocino County—Willits
Leo Mitchell, Warden, Mendocino County—Point Arena
J. W. Harbuck, Warden, Napa County—Napa
Bert Laws, Warden, Sonoma County—Petaluma
Victor Von Arx, Warden, Sonoma County—Santa Rosa
Jack Sawyer, Warden, Sonoma County—Cloverdale

Southern Division

O. P. Brownlow, Captain—Alameda
C. L. Bundock, Warden, Alameda County—Oakland
Ed Clements, Warden, Contra Costa County—Martinez
Owen Mello, Warden, Monterey County—Pacific Grove
Henry Ocker, Warden, Monterey County—King City
F. H. Post, Warden, Monterey County—Salinas
J. P. Vissiere, Warden, San Benito County—Hollister
Lee C. Shea, Warden, San Francisco County—San Francisco
C. R. Peek, Warden, San Mateo County—San Mateo
M. S. Clark, Warden, Santa Clara County—Palo Alto
C. E. Holladay, Warden, Santa Clara County—San Jose
F. J. McDermott, Warden, Santa Cruz County—Santa Cruz
J. E. Hughes, Warden, Solano County—Dixon
R. C. O'Connor, Warden, San Francisco County—San Francisco

SOUTHERN DISTRICT (Headquarters, Los Angeles)

Earl Macklin, Captain in Charge—Los Angeles
E. H. Ober, Captain, Special Duty—Los Angeles
F. W. Hecker, Captain—San Luis Obispo

Western Division

L. T. Ward, Captain—Escondido
Fred Albrecht, Warden, Los Angeles County—Los Angeles
Walter Shannon, Warden, Los Angeles County—Los Angeles
Walter Emerick, Warden, Los Angeles County—Palmdale
Theodore Jolley, Warden, Orange County—Orange
E. H. Glidden, Warden, San Diego County—San Diego
Chester Parker, Warden, San Diego County—Julian
R. E. Bedwell, Warden, Santa Barbara County—Santa Barbara
W. Greenwald, Warden, Ventura County—Fillmore
John Spicer, Warden, Ventura County—Ojai
Orben Philbrick, Warden, San Luis Obispo County—Paso Robles

Eastern Division

H. C. Jackson, Captain—San Bernardino
Leo Rossier, Warden, Imperial County—El Centro
W. S. Talbott, Warden, Inyo County—Bishop
C. J. Walters, Warden, Inyo County—Independence
James Loundagin, Warden, Mono County—Leevining
W. C. Blewett, Warden, Riverside County—Indio
W. L. Hare, Warden, Riverside County—Elsinore
A. L. Stager, Warden, San Bernardino County—Upland
W. C. Malone, Warden, San Bernardino County—San Bernardino
Erol Greenleaf, Warden, San Bernardino County—Big Bear Lake
Otto Rowland, Warden, San Bernardino County—Victorville

MARINE PATROL

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Lars Weseth, Master, M.V. *N. B. Scofield* ..... Terminal Island
Kenneth Webb, Warden ..... San Diego
Kenneth Hooker, Warden, Cruiser *Rainbow III* ..... San Rafael
Otis Wright, Assistant Warden, Launch *Sturgeon* ..... Monterey
Walter Engelke, Captain and Warden, Cruiser *Bonito* ..... Santa Monica
Robert Mills ..... Santa Barbara
Ellis Berry, Warden ..... Monterey
W. J. Black, Warden ..... Fairfield
J. R. Cox, Warden ..... Watsonville
N. C. Kunkel, Warden ..... Terminal Island
Leslie E. Lahr, Warden ..... Terminal Island
Ralph Miller Warden ..... San Francisco
Tate F. Miller, Warden ..... Terminal Island
T. W. Schilling, Warden ..... Terminal Island
G. R. Smalley, Warden ..... Richmond
T. J. Smith, Warden ..... San Diego
L. G. Van Vorhis, Warden ..... Terminal Island
E. L. Walker, Warden ..... Terminal Island
Frank Felton, Assistant Warden ..... San Diego

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Paul A. Shaw, Chemical Engineer ..... San Francisco
Don Hall, Warden ..... Oakland
H. L. Lantis, Warden ..... Long Beach
R. L. Schoen, Warden ..... Wilmington
Walter R. Krukow, Assistant Warden ..... Santa Barbara
J. A. Reutgen, Assistant Warden ..... Martinez

MARINE PATROL AND RESEARCH BOATS

Cruiser *Bonito*, Newport Harbor

Cruiser *Rainbow III*, San Rafael

Launch *Sturgeon*, Monterey

Launch *Shrapnel*, Suisun

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