CALIFORNIA FISH AND GAME

"CONSERVATION OF WILDLIFE THROUGH EDUCATION"

VOLUME 48 JANUARY, 1962 NUMBER 1

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CALIFORNIA FISH AND GAME

VOLUME 48 JANUARY, 1962 NUMBER 1

Published Quarterly by
THE RESOURCES AGENCY OF CALIFORNIA
CALIFORNIA DEPARTMENT OF FISH AND GAME
SACRAMENTO

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RECOGNITION AND RETURN OF TROUT TAGS BY CALIFORNIA ANGLERS[1]

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INTRODUCTION

Mortality and harvest rates, as well as total catch of fish, are often calculated on the basis of tags returned voluntarily by anglers. Too often, the fishery worker assumes that all anglers are alike in their power of observation, and interest and responsiveness to follow the directions given on a tag. The fishery worker sometimes makes no distinction between one area and another or between seasons in the same fishery. On a larger scale, he sometimes makes no distinction between these factors from fishery to fishery.

Most fishery workers do not have either the time or the knowledge of human behavior to evaluate the observation and response reactions of anglers. Nevertheless, they must consider these factors in the anal-

[1] Submitted for publication June, 1961. This work was performed as part of Dingell-Johnson Project California F-8-R, "Trout Management Study", supported by Federal Aid to Fish Restoration funds.

TABLE 1
Angler Nonresponse of Tag Returns, Based Upon Voluntary Tag Returns Versus Calculated or Actual Harvest in the Same Water

Water	Reference	Date	Number of fish	Method of determining percentage return	Percentage return	Percentage* of non-response
Convict Lake	von Geldern and Kabel, 1960	7/1/58	2,400	DeLury estimate	90.1	
		8/27/56	400	Voluntary tag return	42.2	53.2
Lagunitas Lake	Fisher, MS	7/23/57	5,000	Partial census	89.9	
		7/23/57	300	Voluntary tag return	26.3	70.8
	Fisher, MS	9/16/57	5,000	Partial census	74.5	
		9/16/57	300	Voluntary tag return	7.0	90.6
West Fork San Gabriel River	Giguere, MS	7/16–8/10 1954	6,050	Complete creel check	93.4	
		5/28/57	300	Voluntary tag return	12.3	86.8
South Lake	Delisle, 1959	8/8/57	2,500	DeLury estimate	74.0	
		8/22/57	400	Voluntary tag return	16.8	77.3
Upper Rush Creek	Delisle, 1959	8/26/57	2,250	DeLury estimate	90.0	
		6/28/57	400	Voluntary tag return	20.0	77.8
Lake Gregory	von Geldern, 1961	6/28/57	2,800	DeLury estimate	83.0	
		6/28/57	200	Voluntary tag return	44.5	46.4

* The percentage of nonresponse is based upon the assumptions that the first percentage return in each of the above pairs is a valid measure of total fish taken and, within narrow limits, that the percentage of fish caught for the time periods compared above is characteristic of the fishery.

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ysis of data obtained from voluntary tag returns from any tagging study.

During the course of 76 tagging studies on plants of catchable-sized trout in 17 California lakes and streams (Appendix), it became apparent that voluntary tag returns did not reflect the true percentage returns of planted fish. Furthermore, the number of tags returned was not constantly proportional to the number of tagged trout actually caught (Table 1).

In an effort to find techniques that would reduce nonrecognition or nonresponse, different colored tags, different means of identifying the tagged trout, and different programs to encourage the return of tags were applied to the fisheries of eight lakes and three streams. Some procedures resulted in higher tag returns, while others were ineffective in bringing about a better return.

METHODS

A vinyl plastic, subcutaneous tag (Butler, 1957) was used throughout these studies. When first placed beneath the skin of the belly just anterior to the ventral fins, the tag can be recognized easily. After three to four weeks, the tag is no longer visible; but its location is well defined by heavy pigmentation around the tag area.

Catchable-sized trout in California average 7.5 inches in length or four to six fish per pound. In every study, the tagged trout constituted a regularly scheduled plant, and were tagged one to two days prior to planting. Rainbow trout *(Salmo gairdnerii)* is the only trout species presently used for catchable-sized stocking on a large scale in California, and is the only species used in the studies upon which this report is based. Posting and all tag return inducement programs were well organized and employed prior to the tagging and planting. The poster used during the studies was lettered in red and black on a white fiberboard, 11 by 14 inches in size. A large, tagged trout, with the tag area on the trout clearly defined, was shown. The tag was described and complete instructions for return of the tag were provided the angler (Figure 1, upper left corner). Demonstration boards were provided with a preserved tagged specimen (Figure 1, upper right corner). Franked envelopes were available on the demonstration board if creel checker contacts with the public were not maintained throughout the day (Figure 1, lower left corner). The demonstration boards were placed at resorts, boat docks, stores and public campgrounds.

Local newspaper coverage of the tagging program was provided at Big Bear Lake and Kern River. A $2,000 reward tag program was underwritten by local sportsmen's clubs, business organizations, and others at Kern River, Lake Pillsbury, and Big Bear Lake. These funds covered the payment to anglers for tags clearly identified with the printing on one side "$5 Reward". In addition to the $5-reward-tag program at Big Bear Lake, individual businesses contributed a total of several thousand dollars worth of substantial awards for a tag drawing award program.

In some of the tests, yellow tags were used with green tags. In one study, tags bearing common Christian names were used with numbered tags. Tagged trout that were also marked by the removal of certain fins were planted with unmarked tagged trout in several waters. The tag returns from each of these paired plantings were compared to determine the techniques that obtain the best tag return response. The 95 percent level of confidence was used in testing for significant differences.

FIGURE 1. Demonstration board used in catchable trout tagging studies.

RESULTS

Recognition of Tagged Trout

Any tag to be used successfully on sport fish must be seen readily by the angler. Recognition depends upon color, shape, size, and location of the tag. An external tag is certainly more obvious than a subcutaneous or internal tag; however, external tags may be overlooked also. At the Red Lake commercial fishery in northern Minnesota, Monel metal strap jaw tags were used in a tagging study to determine the characteristics of the walleye population in two distinct but connected bodies of water (Smith, Krefting, and Butler, 1952). Although these were external tags, some of the tags on the walleye passed unnoticed through the hands of commercial fishermen and into the packing and sorting center of the fishery, where they were also missed. Tag returns from some of these fish were obtained from consumers in Chicago who had purchased the fish at the Chicago fish market.

The yellow subcutaneous tag used in the California catchable trout studies is not noted readily by the angler, unless he is looking for it. However, very high tag returns in some of the waters indicate that this need not be a serious objection if sufficient effort is made to inform the angler.

Although the yellow subcutaneous tag can be seen through the skin, the color of the tag blends rather well with the white belly skin. It was thought that the greater color contrast made by green tags would result in higher returns. Subsequent returns did not support this assumption. A plant of 600 yellow tags and 600 green tags, made in three different waters (Table 2) did not result in a significant difference in return. The chi-square value with one degree of freedom was 2.18.

Marked fish are frequently used in trout studies in California; that is, various fins or combinations of fins are removed to identify specific groups of trout. Some anglers readily detect such marks. It was assumed that fin-clipped fish would be examined more closely by the angler. Inasmuch as the ventral fins are the fins most often removed and are very close to the subcutaneous tag, it was believed that tags should be more easily detected on marked trout. The chi-square value for the tags returned from the marked and unmarked tagged trout (Table 2) was 0.78. Although nonsignificance is indicated with this group of returns, a larger sample test (Table 3) gave a significantly higher return of tags from the marked trout.

TABLE 2

The Return of Yellow and Green Subcutaneous Tags From Marked and Unmarked Catchable Trout From Three Lakes (June, Mary, and South) of Inyo-Mono Counties, California, 1957

Number planted	Color	Ventral fin condition	Number returned	Percentage returned
300	Yellow	Removed	54	18.0
300	Yellow	Not removed	48	16.0
300	Green	Removed	64	21.3
300	Green	Not removed	58	19.3

TABLE 3
Return of Tags From Marked and Unmarked Trout

Water	Condition	Number planted	Number returned	Percentage returned
West Fork San Gabriel River	Marked	150	27	18.0
Big Bear Lake	Marked	398	131	32.9
South Lake	Marked	200	36	18.0
Lake Mary	Marked	200	24	12.0
June Lake	Marked	200	58	29.0
Totals		1,148	276	24.0
West Fork San Gabriel River	Unmarked	150	10	6.7
Big Bear Lake	Unmarked	399	117	29.3
South Lake	Unmarked	200	31	15.5
Lake Mary	Unmarked	200	22	11.0
June Lake	Unmarked	200	53	26.5
Totals		1,149	233	20.3

The change from nonsignificance to significance in the two previous tests is most likely due to the nature of the samples. In the first study, June Lake was the only water that had been planted previously with marked fish. In the second study, all waters—with the exception of Lake Mary—had been stocked previously with marked fish. Studies of marked trout had been common to the waters of Big Bear Lake and the West Fork of the San Gabriel River. Most likely, the significant difference of tag returns between marked and unmarked trout is a reflection of anglers conditioned to note marked trout. One could not expect significantly higher returns of marked tagged trout over unmarked tagged trout from waters whose anglers had not been conditioned to marked trout.

Tags as Mementos or Charms

Sometimes an angler desires to keep a tag as a memento or charm. This does not happen often, but it is conceivable that in some areas it may be an important factor against the return of tags. The previously mentioned Red Lake studies experienced this problem in an exaggerated form. During the first year of the work, it was found that the Red Lake Indians preferred to keep the Monel metal strap tags. Some Indians were observed wearing large strands of beads made from the tags. Data from these tags were not available. Later, when these people had accepted efforts of the fishery workers as being sincere and for the betterment of their fishery, the tags were turned in.

An angler may keep his tag as a conversation piece or as a memento, rather than return it. If one can create in the angler a curiosity to know more about his tagged fish, the tag returns are more likely to represent the actual catch.

Traditionally, tags are numbered. It was thought that changing tag numbers to simple Christian or first names of people, such as "John" or "Jane", might increase the curiosity of anglers to return more tags. The exploratory attempt to obtain information of this nature was made with a plant of 200 catchable-sized trout in Strawberry Lake, Tuolumne County. The tags were identical in shape, size, and return instruction but differed in that one set of tags bore serial numbers and the other set bore first names of people. Chi-square analysis of the return of these two groups indicated no significant difference in response.

Inducement for Tag Returns

Several devices have been used to encourage the return of tags. Smith and Smith (1945) and Mullan (1959) indicate that tag return boxes along a trout stream result in an increase of the return of tags and give a better index to the number of tagged fish actually caught.

In some of the California studies discussed here, franked envelopes were provided at convenient angler access points. Although more tags were returned through the use of franked envelopes than through personal stationery, it was not possible to judge to what extent franked envelopes increased tag returns.

Reward tags have been used frequently as an inducement for the return of tags in the salmon fisheries of the West Coast of North America. In the striped bass fishery of the San Francisco Bay area, Chadwick (1960) found that nonreward tags returned only 60 percent as well as $5-reward tags. External (Peterson disk) tags were used for both the reward and nonreward tags, so recognition should not have been a factor in the difference in return.

Five-dollar-reward tags were used in three catchable trout fisheries during 1956 and 1957. On the Kern River, above Lake Isabella, 175 fish bearing $5-reward tags were planted with 3,048 fish carrying numbered tags. These were distributed throughout the season among eight different plants. Return of the nonreward tags amounted to 33.1 percent and reward tags 53.7 percent (Table 4). Chi-square analysis of these two lots indicated a significant difference in return. If the return of reward tags represents the true catch of tagged fish, there was a nonresponse of 38.4 percent for the nonreward tags.

One may question the validity of chi-square analyses for such a small sample of reward tags, compared with a large number of nonreward tags. Variance of small samples is large, in comparison with larger sample sizes. This is true if the sampling is done at random. However,

TABLE 4

The Returns of Non-reward and Five-dollar-reward Tags From Catchable-sized Trout Planted in the Kern River Above Lake Isabella

Date	NON-REWARD TAGS Number tagged	NON-REWARD TAGS Number returned	NON-REWARD TAGS Percentage returned	REWARD TAGS Number tagged	REWARD TAGS Number returned	REWARD TAGS Percentage returned
6/21/56	168	138	29.5	20	10	50
7/5/56	190	173	35.3	25	16	64
7/26/56	490	254	51.8	25	17	68
8/9/56	300	101	33.7	15	11	73
8/22/56	500	205	41.0	25	11	44
10/18/56	300	44	14.7	15	6	40
4/1/57 and 4/21/57	500	94	18.8	50	23	46
Totals	3,048	1,009	33.1	175	94	53

random variability was not exhibited in the returns from these catchable trout. Inasmuch as the Kern River fishery is intense, virtually the complete population of planted fish is removed in a relatively short time. The percentage return of reward tags in each of the eight different plants was higher than the percentage returned from the nonreward tag group. If there was no real significant difference and if random variation of return was present, one would expect the percentage return of reward tags occasionally to fall below those of nonreward tags. Therefore, it is assumed that normal restrictions on the use of small samples is not a serious objection in this instance.

Another $5-reward-tag program was carried out at Lake Pillsbury, Lake County (Kabel, 1960). Here, 100 $5-reward tags were used with 3,700 nonreward tags in two plants of trout. This water has the lowest angler pressure that has been observed in California lakes stocked with catchable-sized trout. The extremely low angler pressure of 0.2 angler hours per acre per day produced an instantaneous fishing mortality rate amounting to only one-thirtieth of the lowest rate noted for the Kern River catchable trout fishery. The fishery did not take a large percentage of the planted trout.

Although most of the trout caught in Lake Pillsbury are wild trout (Evans, 1957), three resorts on the lake not only supported the $5-reward-tag program financially but also participated actively in checking for tags and querying visitors about the trout they had caught. Campers from the one public camp site visited these resorts for supplies and for information on fishing conditions. They were also exposed to posters and demonstration boards at the campground and around the lake. Creel checkers were in the area two times each day, and on the lake during many hours of the day.

Chi-square values for reward tag versus nonreward tag return showed no significant difference. Although the tag returns were low (Table 5), and therefore subject to greater error than if they had been higher, it is reasonable to assume the nonsignificance of return would have been maintained even with a higher percentage return, because of the extensive effort made to obtain tags.

It is not always possible to obtain funds for a monetary reward-tag-return program. In lieu of such financial support, tag-drawing-award programs are often developed. If the awards are impressive and the advertising is intensive, such effort may well replace the use of reward

TABLE 5

The Returns of Non-reward and Five-dollar-reward Tags From Catchable-sized Trout Planted in Lake Pillsbury, Lake County (Kabel, 1960)

	NON-REWARD			REWARD		
Date	Number tagged	Number returned	Percentage returned	Number tagged	Number returned	Percentage returned
4/26/57	2,700	699	25.9	50	13	26
6/27/57	1,000	87	8.7	50	7	14
Totals	3,700	786	21.2	100	20	20

FIGURE 2. Big Bear Lake Chamber of Commerce display window of awards.

tags. Five-dollar-reward and tag-drawing-award programs were carried out simultaneously at Big Bear Lake in 1956. Local people provided financial support for $5-reward tags and several thousand dollars in substantial awards: a boat, boat trailer, several outboard motors, many items of fishing tackle, free lodging, and free meals for bimonthly drawing awards. Only the numbered tags were used in the drawing award program. The program was highly publicized. All local and some Los Angeles newspapers emphasized the value of participating in the award program, as well as participating in the $5-reward-tag program. The awards were placed in a downtown window in the city of Big Bear Lake (Figure 2). Creel checkers informed anglers of the program and checked creels throughout the entire season of 1956. The percentage return of tags from each of these two programs was practically the same (Table 6); 66.9 percent of the drawing-award tags and 68 percent of the $5-reward tags were returned.

During 1957, an award program was again carried out but without an accompanying reward tag program or extensive creel checking. The return of tags during 1957 was consistently below the level of tag returns during 1956. The lower returns are believed to result from lower tag return inducement.

DISCUSSION

Obviously, there is no simple plan or procedure for obtaining tags from anglers. Anglers who participated in the Big Bear Lake reward- and award-tag programs learned of the study primarily through the newspapers. Departmental posters and fishermen provided the second most important source (Table 7). The award winners learned of the location of tags principally through the Fish and Game posters and other fishermen. Newspapers played a very minor role in conveying this information.

In spite of their intensive work at Big Bear Lake, Department of Fish and Game personnel apparently had very little effect in direct passage of information to anglers. Although they did not make many effective contacts with the winners, their efforts may have been expressed via fisherman-to-fisherman contact.

Any contact with anglers, whether direct or indirect, is undoubtedly important. Talks given in the local communities may greatly influence

TABLE 6

The Return of Drawing-award and Five-dollar-reward Tags From Simultaneous Plants of Trout at Big Bear Lake, San Bernardino County

	DRAWING AWARD			REWARD TAGS		
Date	Number tagged	Number returned	Percentage returned	Number tagged	Number returned	Percentage returned
5/15/56	502	335	66.7	25	17	68
5/31/56	391	257	65.7	25	14	56
6/20/56	490	336	68.6	25	16	64
8/22/56	597	396	66.3	25	21	84
Totals	1,980	1,324	66.9	100	68	68
4/ 4/57*	399	120	30.1	--	--	--
4/ 4/57	398	164	41.2	--	--	--
4/30/57	499	199	39.9	--	--	--
5/29/57	400	144	36.0	--	--	--
7/ 3/57	399	103	25.8	--	--	--
Totals	2,095	730	34.8	--	--	--

* Plant comprised of fish averaging one pound each.

TABLE 7

Answers Received From Award and Five-dollar-reward Tag Winners Who Participated in the Big Bear Lake Tagging Study, 1956

Did you know tagged fish were in lake before you began fishing?	
Yes	46
No	6
From what source did you learn of the tagging study?	
Newspaper	22
Fish and Game posters	14
Other fishermen	15
Fish and Game personnel	3
Chamber of Commerce display	4
Other	6
Did you know where to look for the tag?	
Yes	43
No	9
From what source did you learn of tag's appearance?	
Newspaper	4
Fish and Game posters	18
Other fishermen	18
Fish and Game personnel	9
Chamber of Commerce display	2
Other	11

TABLE 8
Decreased Percentage Return of Tags Under Constant or Decreased Tag Return Effort

Water	Date	Percentage return
June Lake	1956	52.5
	1957	27.8
Big Bear Lake	1956	66.9
	1957	34.8
Lake Lagunitas	7/23/57	26.3
	9/16/57	7.0

tag return response. Such talks may overcome indifference, antipathy, or outright antagonism if the local community can see some benefit to themselves. Local community interest will then in turn affect the visiting angler.

Without continuous effort to keep up angler response, a drop in tag return may obscure the actual catch of tagged fish. Perhaps people tire of such programs, or the questions held earlier by the local people and anglers may have been answered. At June Lake, Big Bear Lake, and Lake Lagunitas, fewer tags were returned from tagging studies which followed previous tagging recovery work (Table 8). It is doubtful that these lower returns are a reflection of poorer survival of planted fish. The lower tag returns most likely resulted from a reduced tag return recovery effort and loss of novelty to the anglers.

CONCLUSIONS

The number of tagged fish caught and the number of tags returned are seldom, if ever, the same, and the relationship between these two values also varies widely. Even if one assumes he has a perfect tag from the standpoint of retention and recognition, the angler response in returning these tags may vary widely. The number of tags returned by anglers depends largely upon the amount and type of effort made to recover tags from anglers. The return of tags is also related to the amount of interest of anglers, resort owners, and others in a particular fishery. Tag return response is primarily a problem in human behavior.

The fisheries biologist should attempt to maintain the same level of angler response throughout a tagging study. Any change in effort on his part or others is likely to upset any calculation related to total catch (Ricker, 1948). If he can measure the level of nonresponse and maintain or control it, his data will be much more valuable.

SUMMARY

1. Since the return of tags by anglers does not always represent the actual catch of tagged fish, some approaches were made to determine what factors are important in the recognition of tags and what factors encourage the return of tags by anglers.

2. Vinyl plastic subcutaneous tags were used on planted catchable-sized rainbow trout throughout the tests on eight lakes and three

streams. In an effort to find techniques that would reduce nonrecognition and nonresponse, different colored tags, different means of identifying the tags and tagged trout, and different programs to encourage the return of tags were applied in some manner to the 11 fisheries.

3. Green tags, assumed to be more obvious to anglers, were not returned in greater numbers than yellow tags.
4. Marked (fin-clipped) tagged trout may be more readily recognized than unmarked tagged trout in fisheries where marked fish have been previously used. Larger tag returns of marked trout are unlikely in those fisheries where no previous studies with marked fish have been made.
5. Tags bearing common given names of people did not return any better than numbered tags.
6. Five-dollar-reward tags were returned better than non-reward tags in the Kern River study. Five-dollar-reward tags were not returned any better than non-reward tags at Big Bear Lake where a chance to participate in a drawing for valuable prizes was made possible by the return of non-reward tags.

   Five-dollar-reward tags were not returned any better than non-reward tags at Lake Pillsbury—a low return, low angler pressure fishery.
7. The recognition of tagged fish and response in returning tags from tagged fish is a problem in human behavior. The fishery biologist should attempt to establish the level of nonrecognition and/or nonresponse. He should control these factors during the course of a tagging study if percentage return or mortality rates are calculated from the return of tags.
8. There appears to be no one technique that will guarantee consistent returns of the tags from tagged fish caught by anglers.

ACKNOWLEDGMENTS

A study of this nature without interested and helpful individuals is impossible.

Charles Tayles recognized the need for a tag return program at Big Bear Lake. His interest and encouragement brought a group together for the development of a reward and award program of unusual magnitude.

Ardis Walker, in like manner, led his community in support of the reward tag program on the Kern River. Harold Boyd, Howard Tanner, Claude Tarvin and Jack Cartwright of Pillsbury Lake devoted much personal time, funds and effort to the tagging program there.

Although inconvenienced by the tagging program, hatchery personnel of the Department of Fish and Game cheerfully assisted in every way. Because much of the work originated at Mojave and Kernville hatcheries, I should like to express my thanks to E. A. Friedrichsen and C. Ray of these installations.

REFERENCES

Butler, Robert L.
1957. The development of a vinyl plastic subcutaneous tag for trout. Calif. Fish and Game, vol. 43, no. 3, pp. 201-212.

Chadwick, Harold K.
1960. Progress report of the striped bass tagging study. Calif. Dept. Fish and Game, Inland Fisheries Branch, Admin. Rept. no. 60-1, 35 pp. (Mimeo.)

Delisle, Glenn E.
1959. Catchable trout evaluation studies in Inyo-Mono Counties, 1957. Calif. Dept. Fish and Game, Inland Fisheries Branch, Admin. Rept. no. 59-7, 41 pp. (Mimeo.)

Evans, Willis A.
1957. The 1956 studies at Lake Pillsbury, Lake County. Calif. Dept. Fish and Game, Inland Fisheries Branch, Admin. Rept. no. 57-30, 12 pp. (Mimeo.)

Fisher, Charles K.
MS Evaluation of the 1957 catchable trout program in Lagunitas Lake, Marin County.

Giguere, Paul E.
MS A short term study of catchable trout plants in the West Fork of the San Gabriel River, Los Angeles County.

Kabel, C. S.
1960. Catchable trout studies at Lake Pillsbury, Lake County, 1957. Calif. Dept. Fish and Game, Inland Fisheries Branch, Admin. Rept. no. 60-12, 74 pp.

Mullan, James W.
1959. Probable effectiveness of tag reporting from trout stocked in two Massachusetts stream drainages. Mass. Div. Fish and Game, 13 pp. (Unpublished report) (Mimeo.)

Ricker, William E.
1948. Methods of estimating vital statistics of fish populations. Indiana Univ. Publ. Sci. Ser., no. 15, 101 pp.

Smith, Lloyd L., Jr., and Beatrice S. Smith
1945. Survival of seven to ten inch planted trout in two Minnesota streams. Amer. Fish. Soc., Trans., vol. 73, pp. 108-116.

Smith, Lloyd L., Jr., Laurits W. Krefting and Robert L. Butler
1952. Movements of marked walleyes, *Stizostedion vitreum vitreum* (Mitchill), in the fishery of the Red Lakes, Minnesota. Amer. Fish. Soc., Trans., vol. 81, pp. 179-196.

von Geldern, Charles, Jr.
1961. A new approach to estimating returns of catchable trout. Amer. Fish. Soc., Trans., vol. 90, no. 3, pp. 259-263.

von Geldern, Charles, Jr., and C. S. Kabel
1960. The 1958 Convict Lake creel census. Calif. Dept. Fish and Game, Inland Fisheries Branch, Admin. Rept. no. 60-2, 31 pp. (Mimeo.)

APPENDIX

TABLE A-1
Tag Returns From Plants of Catchable-sized Trout in California Waters, 1955 Through 1957

Region	Water	County	Date of plant	Number of tagged trout in plant	Percentage return of tags
I	Castle Lake	Siskiyou	6/15/55	980	35.8
II	South Fork Yuba River	Placer-Nevada	4/18/55	604	43.2
			6/30/55	534	54.5
			7/14/55	535	47.1
			7/28/55	609	50.7
			8/15/55	101	45.5
			8/16/55	191	24.6
	South Fork American	El Dorado	6/28/55	392	42.6
			7/12/55	113	29.2
			7/26/55	586	38.4
			8/10/55	602	49.7
			8/23/55	288	27.8
			8/24/55	295	28.8
	Halsey Forebay	Placer	8/25/55	100	27.0
	Packer Lake	Sierra	6/22/55	180	16.7*
			6/23/55	295	41.0
III	Lake Pillsbury	Lake	4/56 and 7/56	1,650 (4 plants)	6.1
			4/26/57	50†	26.0
			4/26/57	2,700	25.9
			6/27/57	50†	14.0
			6/27/57	1,000	8.7
	Lagunitas	Marin	7/23/57	300	26.3
			9/16/57	300	7.0
IV	Strawberry Lake	Tuolumne	7/18/56	200	11.0
	Kern River above Isabella Lake (Lower Section)	Kern	6/13/56	300	23.0
	(Upper Section)	Tulare	6/14/56	191	36.0
	(Dewatered Section between Fairview Dam and Kern River Powerhouse Number 1)	Tulare-Kern	6/21/56	468	29.5
			6/21/56	20†	50.0
			7/5/56	490	35.3
			7/5/56	25†	64.0
	(Upper Section)	Tulare	7/26/56	490	51.8
			7/26/56	25†	68.0
	(Lower Section)	Kern	8/9/56	300	33.7
			8/9/56	15†	73.0
	(Upper Section)	Tulare	8/22/56	300	44.0
	(Upper and Lower)		8/22/56	25†	44.0
	(Lower Section)	Kern	8/22/56	200	40.0
	(Upper Section)		10/18/56	200	15.0
	(Lower Section)			100	14.0
				15†	40.0

TABLE A-1

Tag Returns From Plants of Catchable-sized Trout in California Waters, 1955 Through 1957—Continued

Region	Water	County	Date of plant	Number of tagged trout in plant	Percentage return of tags
IV con't.	(Upper Section)		11/13/56	250	19.6
	(Lower Section)			250	6.4
	(Upper and Lower)		4/4/57	250	17.2
			4/4/57	25†	
			4/24/57	25†	46.0
			4/24/57	250	20.4
V	Big Bear Lake	San Bernardino	11/1/55	789	22.4
			12/8/55	729	32.2
			3/19/56	495	65.9
			4/26/56	25†	80.0
			5/15/56	502	66.7
			5/15/56	25†	68.0
			5/31/56	391	65.7
			5/31/56	25†	56.0
			6/20/56	490	68.6
			6/20/56	25†	64.0
			7/5/56	397	62.7
			8/21/56	393	64.4
			8/22/56	597	66.3
			8/22/56	25†	84.0
			4/4/57‡	399	29.3
			4/4/57	398	41.2
			4/30/57	499	39.9
			5/29/57	400	36.0
			7/3/57	399	26.1
	West Fork San Gabriel	Los Angeles	5/28/57	300	12.3
	Rush Creek	Mono	6/28/57	400	20.0
	Lake Gregory	San Bernardino	6/28/57	200	44.5
	June Lake	Mono	8/27/56	400	52.5
			8/8/57	400	27.8
	Convict Lake		8/27/56	400	42.2
	Twin Lakes		8/27/56	400	42.2
	Lake Mary		8/19/57	400	11.5
	South Lake	Inyo	8/22/57	400	16.8

* Kamloops trout

† $5-reward tag

‡ Private hatchery trout

THE NAMES OF CERTAIN MARINE FISHES OF CALIFORNIA[1]

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California has for many years assigned official common names to the more important of its fishes. The original purpose—and still a primary one—was to assist in compiling commercial fisheries statistics, because these provide the basis for many of the State's studies of its marine resources. Without catch figures, such studies are made impossible or exceedingly difficult. Without a uniform terminology, such statistics as one may have are no better than his knowledge of vernacular.

In 1917, when California instituted its recording system for commercial landings, an untold number of common names was in use among commercial fishermen. In an effort to bring ultimate order to a chaotic situation, the State Legislature in 1919 enacted a law empowering the Fish and Game Commission to select common usage names for any variety of fish. In 1933, this law was amended to substantially its present form and its application limited to commercial varieties in connection with fish receipts. It now forms section 8013 of Part 3 (Commercial Fishing) of Division 6, Fish and Game Code and reads:

"The names used in the receipt for designating the species of fish dealt with must be those in common usage, and may be designated by the department."

Despite the limitation of the present law to commercial species, the Department has assigned common names to other than commercial varieties, both freshwater and marine, to insure uniformity in State publications and records and in an attempt to attain common usage on the part of all fishermen. You cannot legislate common usage, but through constant repetition of approved names a remarkable degree of uniformity has emerged.

The most recent official marine list was published eight years ago (Roedel, 1953). It was not a complete roster of the ocean fishes known from the State—this was felt unnecessary—but it did cover those species likely to be seen or taken by commercial and sport fishermen. A complete list of freshwater and anadromous fishes appeared in 1950 (Shapovalov and Dill); it was revised in 1959 (Shapovalov, Dill and Cordone).

The 1953 marine list has needed minor alteration for several years; a few of the names proposed in it proved ill-chosen, the scientific nomenclature has undergone some revision and a few unlisted species have come into prominence.

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[1] Submitted for publication May 1961.

In the meantime, a joint committee of the American Fisheries Society and the American Society of Ichthylogists and Herpetologists had been preparing a list of common and scientific names for all the fishes of the United States and Canada. The result of this work appeared recently (American Fisheries Society, 1960), replacing that organization's first list (AFS, 1948). Insofar as the California's marine fishes are concerned, the great majority of the names were in conformity with California's list. A number of minor aberrations appeared; a few names, both common and scientific, were at variance with usage in this state.

No one knew better than the committee members that the American Fisheries Society list would not be the ultimate word. It did, in fact, stimulate preparation of this publication the purpose of which is several-fold. It proposes:

(1) to bring up-to-date the 1953 list;
(2) to provide a relatively short official list of the more significant marine and anadromous fishes of the state;
(3) to provide names for a few of the more common fishes of Baja California and the Gulf of California which are of interest to California fishermen (this area was excluded from the American Fisheries Society list);
(4) to provide names for some of the small fishes that have come into prominence as aquarium varieties and which are sought by skin and SCUBA divers;
(5) to point out the reasons for not accepting American Fisheries Society names where such action was not considered practical.

As a general rule, the list includes only those species likely to be caught by commercial and sport fishermen either by design or by accident. The sharks, rays, rockfishes and surfperches, all of which include some little-known species, are listed in their entirety because names have been given all representatives in previous Department publications.

Unlisted species are obscure (so far as man is concerned) or rare and at present are of concern only to the professional ichthyologist. The common names selected by the American Fisheries Society should be used for such of these fishes as it included. The society, however, limited its list to those species found in 100 fathoms or less. Consequently, common names are not available for many pelagic and benthic species.

Principles governing the selection of names have been discussed by Roedel (1953), Shapovalov, Dill and Cordone (1959), and the American Fisheries Society (1960). In a few instances in the present list, alternative names have been sanctioned. The preferred name is given primary listing.

Optional attributives, enclosed in parentheses, appeared in the 1953 list. These were used to show that another species with the same basic vernacular was found outside of the State's boundaries. They are not employed in this revision. The annotations in the list explain changes from the official list of 1953 and variations from the American Fisheries Society list of 1960.

The list has been arranged like that of the American Fisheries Society to facilitate comparison of the two. Family names and groupings were taken uncritically from it, and species have been arranged alphabetically by scientific name within families.

The abbreviations CFG and AFS refer respectively to the 1953 California list (Roedel) and the 1960 list of the American Fisheries Society.

CLASS AGNATHA—JAWLESS FISHES

ORDER MYXINIFORMES

Myxinidae—hagfishes

Black hagfish *________________ *Polistotrema deani* Evermann and Goldsborough

Pacific hagfish *________________ *Polistotrema stouti* (Lockington)

CLASS CHONDRICHTHYES—CARTILAGINOUS FISHES

ORDER SQUALIFORMES

Hexanchidae—cow sharks

Sixgill shark________________ *Hexanchus griseum* (Bonnaterre)

Sevengill shark________________ *Notorynchus maculatus* Ayres

Both this and the sixgill were listed as cowsharks in CFG. AFS preferred the simpler terminology with which we concur.

Chlamydoselachidae—frill sharks

Frill shark________________ *Chlamydoselachus anguineum* Garman

Heterodontidae—horn sharks

Horn shark________________ *Heterodontus francisci* (Girard)

CFG employed the optional attributive "California;" this seems unnecessary.

Lamnidae—mackerel sharks

Thresher shark________________ *Alopias vulpinus* (Bonnaterre)

(Common) thresher in CFG. AFS, for reasons which strike us as sound, avoids "common" as an attributive; we concur here and elsewhere. The fish is usually called "thresher" alone and that usage is sanctioned.

Great white shark________________ *Carcharodon carcharias* (Linnaeus)

"Man-eater" in CFG but this species is, unfortunately, not the only man-eater on our coast. Great white shark now appears predominant in California. The AFS listing of "white shark" strikes us as a bit pallid.

Basking shark________________ *Cetorhinus maximus* (Gunnerus)

Bonito shark________________ *Isurus glaucus* (Müller and Henle)

Salmon shark________________ *Lamna ditropis* Hubbs and Follett

Rhincodontidae—whale sharks

Whale shark *________________ *Rhincodon typus* Smith

Scyliorhinidae—cat sharks

Brown cat shark________________ *Apristurus brunneus* (Gilbert)

Swell shark________________ *Cephaloscyllium uter* (Jordan and Gilbert)

CFG employed the optional attributive "California" which seems unnecessary.

Filetail cat shark________________ *Parmaturus xaniurus* (Gilbert)

Carcharhinidae—requiem sharks

Roundnose shark________________ *Carcharhinus azureus* (Gilbert and Starks)

Bay shark________________ *Carcharhinus lamiella* (Jordan and Gilbert)

Tiger shark________________ *Galeocerdo cuvieri* (Peron and LeSueur)

* Not previously listed.

Soupfin shark .... *Galeorhinus zyopterus* Jordan and Gilbert
Listed as above in AFS. Soupfin alone in CFG; that usage remains sanctioned.

Gray smoothhound .... *Mustelus californicus* Gill

Sicklefin smoothhound .... *Mustelus lunulatus* Jordan and Gilbert

Blue shark .... *Prionace glauca* (Linnaeus)

Pacific sharpnose shark .... *Scoliodon longurio* (Jordan and Gilbert)

Brown smoothhound .... *Triakis henlei* (Gill)
Rhinotriakis used in CFG. This genus is now generally synonymized with *Triakis* as recommended by Bigelow and Schroeder (1948).

Leopard shark .... *Triakis semifasciata* Girard

Sphyrnidae—hammerhead sharks

Scalloped hammerhead .... *Sphyrna lewini* (Griffith)

Bonnethead .... *Sphyrna tiburo* (Linnaeus)

Smooth hammerhead .... *Sphyrna zygaena* (Linnaeus)
Changed from "common hammerhead" in agreement with AFS; "smooth" because of the rounded central portion of the front margin of the head (opposed to the notched front margin of *lewini*).

Squalidae—dogfish sharks

Prickly shark .... *Echinorhinus cookei* Pietschmann
Listed as bramble shark *E. brucus* in CFG and AFS but all specimens known from California answer Garrick's description (1960) of *cookei*. We suggest prickly shark because of the uniform prickliness of the hide as opposed to the large bramble-like clusters on *brucus*.

Pacific sleeper shark .... *Somniosus pacificus* Bigelow and Schroeder

Spiny dogfish .... *Squalus acanthias* Linnaeus
Simply "dogfish" in CFG, which remains sanctioned. The attributive appears in AFS to separate it from "Cuban dogfish" which also appears therein.

Squatinidae—angel sharks

Pacific angel shark .... *Squatina californica* Ayres
Its distribution is not confined to California; hence the change from CFG's "California angel shark" to this name which agrees with AFS.

ORDER RAJIFORMES

Rhinobatidae—guitarfishes

Thornback .... *Platyrhinoidis triseriata* (Jordan and Gilbert)
"California thornback" in CFG. The attributive seems unnecessary and does not appear in AFS.

Shovelnose guitarfish .... *Rhinobatos productus* (Ayres)

Banded guitarfish .... *Zapteryx exasperata* (Jordan and Gilbert)
Name changed from CFG's "mottled guitarfish" better to describe the color pattern; AFS concurred.

Torpedinidae—electric rays

Pacific electric ray .... *Torpedo californica* Ayres
Formerly "California electric ray" but the distribution extends into Canada; the new name agrees with AFS.

Rajidae—skates

Sandpaper skate .... *Breviraja kincaidi* (Garman)
AFS uses "black skate," a name formerly used in California but dropped in CFG as inappropriate. The skin is not black but more the color and texture of sandpaper. This fish has always before been assigned to genus *Raja*. However, all specimens we have checked fit the description of *Breviraja* given by Bigelow and Schroeder (1953) and Ishiyama (1958).

Big skate .... *Raja binoculata* Girard

California skate .... *Raja inornata* Jordan and Gilbert

Longnose skate—*Raja rhina* Jordan and Gilbert

Starry skate—*Raja stellulata* Jordan and Gilbert

Roughtail skate—*Raja trachura* Gilbert

Dasyatidae—stingrays

Diamond stingray—*Dasyatis dipterurus* (Jordan and Gilbert)

Pelagic stingray *—*Dasyatis violacea* (Bonaparte)

California butterfly ray—*Gymnura marmorata* (Cooper)

Round stingray—*Urolophus halleri* Cooper
Generic name changed from *Urobatis* (CFG) following the recommendation of Bigelow and Schroeder (1953).

Myliobatidae—eagle rays

Bat ray—*Myliobatis californicus* Gill
AFS uses "bat stingray"; we feel bat ray follows more general usage. Genus *Holorhinus* to which this fish was assigned in CFG is not regarded as valid (Bigelow and Schroeder, 1953).

Mobulidae—mantas

Pacific manta—*Manta hamiltoni* (Newman)

Spinetail mobula *—*Mobula japanica* (Müller and Henle)

Smoothtail mobula—*Mobula lucasana* Beebe and Tee Van
Formerly "Pacific mobula." With capture of a second species in California (above) the name was changed and so appears in AFS. The attributives reflect relative development of the sting.

ORDER CHIMAERIFORMES

Chimaeridae—chimaeras

Ratfish—*Hydrolagus colliei* (Lay and Bennett)

CLASS OSTEICHTHYES—BONY FISHES

ORDER ACIPENSERIFORMES

Acipenseridae—sturgeons

Green sturgeon—*Acipenser medirostris* Ayres

White sturgeon—*Acipenser transmontanus* Richardson

ORDER CLUPEIFORMES

Elopidae—tarpons

Machete—*Elops affinis* Regan
CFG listed this as "tenpounder." It occurs in California only in the Colorado River area where it is found sporadically, but is common in Mexican waters where Mexicans and Americans generally call it "machete." This name is employed by Berdegue (1956) and was adopted by general agreement of the AFS committee and Shapovalov *et al.*, then preparing the 1959 California freshwater list, as representing the best vernacular.

Albulidae—bonefishes

Bonefish—*Albula vulpes* (Linnaeus)

Clupeidae—herrings

American shad—*Alosa sapidissima* (Wilson)

Pacific herring—*Clupea pallasi* Valenciennes
AFS regards this fish as a subspecies of *C. harengus.*

Pacific round herring—*Etrumeus acumintus* Gilbert
AFS uses "California round herring", but this fish's distribution extends south to Panama.

* Not previously listed.

Flatiron herring * — *Harengula thrissina* (Jordan and Gilbert)
Pacific thread herring — *Opisthonema libertate* (Günther)
Pacific sardine — *Sardinops caerulea* (Girard)
AFS synonymizes this species with the Japanese *S. sagax*. We retain *caerulea* until the data supporting the change are available for scrutiny.

Engraulidae—anchovies

Deepbody anchovy — *Anchoa compressa* (Girard)
Slough anchovy — *Anchoa delicatissima* (Girard)
Anchoveta — *Cetengraulis mysticetus* (Günther)
Northern anchovy — *Engraulis mordax* Girard

Salmonidae—trouts and salmons

Pink salmon — *Oncorhynchus gorbuscha* (Walbaum)
Chum salmon — *Oncorhynchus keta* (Walbaum)
Silver salmon — *Oncorhynchus kisutch* (Walbaum)
AFS adopted "coho" which prevails in Alaska and Canada. The name is virtually unheard in California but may be used as an alternative.
Sockeye salmon — *Oncorhynchus nerka* (Walbaum)
King salmon — *Oncorhynchus tshawytscha* (Walbaum)
AFS adopted "chinook", the alternative name in CFG. Shapovalov *et al.* (1959), sanction "king" only. Both names are widespread; we retain "king" as the preferred name with "chinook" as alternative.
Coast cutthroat trout — *Salmo clarki clarki* Richardson
AFS does not list subspecies of this fish; we prefer to recognize the coastal sea-run form as deserving of a common name and retain the CFG nomenclature.
Steelhead rainbow trout — *Salmo gairdneri gairdneri* Richardson
By the same token we retain the trinomal and the long accepted common name for sea-run rainbow.

Osmeridae—smelts

Whitebait smelt — *Allosmerus elongatus* (Ayres)
Pond smelt — *Hypomesus olidus* (Pallas)
Both AFS and Shapovalov *et al.* (1959) use this common name, an improvement over "freshwater smelt" of CFG. This species is largely confined to fresh water.
Surf smelt — *Hypomesus pretiosus* (Girard)
Longfin smelt * — *Spirinchus dilatus* Schultz and Chapman
Night smelt — *Spirinchus starksi* (Fisk)
Sacramento smelt — *Spirinchus thaleichthys* (Ayres)
Eulachon — *Thaleichthys pacificus* (Richardson)

Argentinidae—argentines

Pacific argentine * — *Argentina sialis* Gilbert

ORDER MYCTOPHIFORMES

Synodontidae—lizardfishes

California lizardfish — *Synodus lucioceps* (Ayres)

Alepisauridae—lancetfishes

Pacific lancetfish — *Alepisaurus richardsoni* Bleeker

ORDER ANGUILLIFORMES

Muraenidae—morays

California moray — *Gymnothorax mordax* (Ayres)

* Not previously listed.

ORDER BELONIFORMES

Scomberesocidae—sauries

Pacific saury __________________ *Cololabis saira* (Brevoort)

Belonidae—needlefishes

California needlefish ____________ *Strongylura exilis* (Girard)

Exocoetidae—flyingfishes

California flyingfish ____________ *Cypselurus californicus* (Cooper)
Sharpchin flyingfish * ___________ *Fodiator acutus* (Valenciennes)

ORDER CYPRINODONTIFORMES

Cyprinodontidae—killifishes

California killifish ______________ *Fundulus parvipinnis* Girard

ORDER GADIFORMES

Gadidae—codfishes and hakes

Pacific cod ____________________ *Gadus macrocephalus* Tilesius
Pacific hake ___________________ *Merluccius productus* (Ayres)
Pacific tomcod _________________ *Microgadus proximus* (Girard)

ORDER GASTEROSTEIFORMES

Gasterosteidae—sticklebacks

Threespine stickleback * _________ *Gasterosteus aculeatus* Linnaeus

Aulorhynchidae—tube-snouts

Tube-snout * ___________________ *Aulorhynchus flavidus* Gill

Syngnathidae—pipefishes

Kelp pipefish * _________________ *Syngnathus californiensis* Storer
Bay pipefish * __________________ *Syngnathus griseolineatus* Ayres

ORDER LAMPRIDIFORMES

Lamprididae—opahs

Opah _________________________ *Lampris regius* (Bonnaterre)

Trachipteridae—ribbonfishes

Polka-dot ribbonfish * ___________ *Desmodema polystictus* (Ogilby)
Trachipterus polystictus in AFS. Since then Walters and Fitch (1960) have published a revision of the trachipteroids in which they assign the fish to this new genus.

King-of-the-salmon ______________ *Trachipterus trachypterus* (Gmelin)
This name replaces "California ribbonfish" of CFG. "King-of-the-salmon", used by AFS, has appeared in the literature over a period of many years and has as much status in the vernacular as does anything. The fish found off our coast was until recently regarded as a separate species, *T. rexsalmonorum* but recent work has shown it identical with *T. trachypterus*. "King-of-the-salmon" is derived from an Indian legend which attributes to this strangely beautiful fish the power to lead salmon in their migrations.

ORDER PERCIFORMES

Serranidae—sea basses

Spotted cabrilla ________________ *Epinephelus analogus* Gill
Simply "cabrilla" in CFG. This word is used to cover a variety of Mexican fishes and something more specific seemed desirable. The fish has been taken in California since publication of CFG. It appears in AFS under this name.

Gulf grouper ___________________ *Mycteroperca jordani* (Jenkins and Evermann)

* Not previously listed.

Broomtail grouper .... *Mycteroperca xenarcha* Jordan

Kelp bass .... *Paralabrax clathratus* (Girard)

Spotted sand bass .... *Paralabrax maculatofasciatus* (Steindachner)

"Spotted bass" in CFG, which name is used both by AFS and Shapovalov *et al* for *Micropterus punctulatus*. "Spotted sand bass" was used in earlier California publications and appears in AFS.

Sand bass .... *Paralabrax nebulifer* (Girard)

Striped bass .... *Roccus saxatilis* (Walbaum)

Giant sea bass .... *Stereolepis gigas* Ayres

California has used "black sea bass" for this fish for many years. A conflict arose in preparing the AFS list and "black sea bass" was assigned to the Atlantic *Centropristes striatus*. "Giant sea bass", not unheard in connection with this huge fish and certainly an apt name, was concurrently adopted by the Committee.

Branchiostegidae—tilefishes

Ocean whitefish .... *Caulolatilus princeps* (Jenyns)

Carangidae—jacks, scads, and pompanos

Green jack * .... *Caranx caballus* Günther

Mexican scad .... *Decapterus hypodus* Gill

Pilotfish .... *Naucrates ductor* (Linnaeus)

Roosterfish * .... *Nematistius pectoralis* Gill

Recorded once (1959) from California; a prized sportfish in the Gulf of California.

Pacific amberjack * .... *Seriola colburni* (Evermann and Clark)

California yellowtail .... *Seriola dorsalis* (Gill)

Simple "yellowtail" in AFS. We retain the attributive to avoid confusion with Mexican species.

Jack mackerel .... *Trachurus symmetricus* (Ayres)

The optional attributive "Pacific" in CFG is dropped as unnecessary here and in AFS.

Coryphaenidae—dolphins

Dolphinfish .... *Coryphaena hippurus* Linnaeus

"Common dolphinfish" in CFG. We agree with AFS that "common" should be avoided and further that no attributive is necessary. We prefer "dolphinfish" to AFS's "dolphin" because of the confusion otherwise possible as to whether one is speaking of a fish or a mammal. This fish is called *mahi-mahi* in Hawaii and considerable quantities are imported and sold in California under that name.

Bramidae—pomfrets

Pomfret * .... *Brama rayi* (Bloch)

Pomadasyidae—grunts

Sargo .... *Anisotremus davidsoni* (Steindachner)

Salema .... *Xenistius californiensis* (Steindachner)

CFG employed the optional attributive "California."

Sciaenidae—croakers

Bairdiella * ‡ .... *Bairdiella icistius* (Jordan and Gilbert)

This Gulf of California species was introduced into the Salton Sea in 1950 where it is now exceedingly abundant. It is not listed in CFG. Shapovalov *et al.* (1959) refer to it in their text as "gulf croaker", but as a marine species it does not appear in their main list. We and AFS prefer bairdiella, a name which has some currency. Many species of croaker inhabit the Gulf; to distinguish this small fish as the gulf croaker does not seem appropriate even though the name has been used at times in our our publications.

Black croaker .... *Cheilotrema saturnum* (Girard)

Totuava † .... *Cynoscion macdonaldi* Gilbert

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* Not previously listed.
† Not recorded from California.
‡ Gulf of California species established in Salton Sea.

White seabass——— *Cynoscion nobilis* (Ayres)

Scalyfin corvina †——— *Cynoscion othonopterus* Jordan & Gilbert
Gulf corvina in CFG; the new name is far more descriptive.

Shortfin corvina——— *Cynoscion parvipinnis* Ayres

Striped corvina †——— *Cynoscion reticulatus* (Günther)

Orangemouth corvina ‡——— *Cynoscion xanthulus* Jordan and Gilbert

White croaker——— *Genyonemus lineatus* (Ayres)
White croaker was introduced in CFG and picked up by AFS. The fish is still called "tomcod" by many southern California fishermen but that name is reserved for *Microgadus proximus*. Monterey area fishermen refer to it as "kingfish", but on a nationwide basis that is preempted by Atlantic *Menticirrhus*. Regardless of usage elsewhere, "kingfish" is hardly appropriate for this small and generally scorned species.

California corbina——— *Menticirrhus undulatus* (Girard)

Spotfin croaker——— *Roncador stearnsi* (Steindachner)

Queenfish——— *Seriphus politus* Ayres

Yellowfin croaker——— *Umbrina roncador* Jordan and Gilbert

Sparidae—porgies

Pacific porgy *——— *Calamus brachysomus* (Lockington)

Scorpidae—halfmoons

Halfmoon——— *Medialuna californiensis* (Steindachner)

Kyphosidae—sea chubs

Zebra perch *——— *Hermosilla azurea* Jenkins and Evermann

Girellidae—nibblers

Opaleye——— *Girella nigricans* (Ayres)

Embiotocidae—surfperches

Barred surfperch——— *Amphistichus argenteus* Agassiz

Calico surfperch——— *Amphistichus koelzi* (Hubbs)

Redtail surfperch——— *Amphistichus rhodoterus* (Agassiz)

Kelp perch——— *Brachyistius frenatus* Gill

Shiner perch——— *Cymatogaster aggregata* Gibbons

Island perch——— *Cymatogaster gracilis* Tarp
The rule-of-thumb applied since 1953 in naming embiotocids calls for using "surfperch" for those species which are typical surf dwellers, "seaperch" for those associated with the ocean but not primarily with the surf, and "perch" alone for those of varying habitat (including the freshwater "tule perch", *Hysterocarpus traski*). This species is known only from the southern California channel islands. AFS calls it "island seaperch" but we still feel it belongs more properly in the general "perch" category.

Black perch——— *Embiotoca jacksoni* Agassiz

Striped seaperch——— *Embiotoca lateralis* Agassiz

Spotfin surfperch——— *Hyperprosopon anale* Agassiz

Walleye surfperch——— *Hyperprosopon argenteum* Gibbons

Silver surfperch——— *Hyperprosopon ellipticum* (Gibbons)

Rainbow seaperch——— *Hypsurus caryi* (Agassiz)

Reef perch——— *Micrometrus aurora* (Jordan and Gilbert)

Dwarf perch——— *Micrometrus minimus* (Gibbons)

Sharpnose seaperch——— *Phanerodon atripes* (Jordan and Gilbert)

White seaperch——— *Phanerodon furcatus* Girard

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* Not previously listed.
† Not recorded from California.
‡ Gulf of California species established in Salton Sea.

Rubberlip perch .... *Rhacochilus toxotes* Agassiz
"Seaperch" to AFS but in deference to its varied habitat we retain "perch."

Pile perch .... *Rhacochilus vacca* (Girard)

Pink seaperch .... *Zalembius rosaceus* (Jordan and Gilbert)

Pomacentridae—damselfishes

Blacksmith .... *Chromis punctipinnis* (Cooper)

Garibaldi .... *Hypsypops rubicunda* (Girard)

Labridae—wrasses

Rock wrasse .... *Halichoeres semicinctus* (Ayres)

Señorita .... *Oxyjulis californica* (Günther)

California sheephead .... *Pimelometopon pulchrum* (Ayres)
"Sheep-head" in CFG, and "sheepshead" before that in our publications. This latter is used for an Atlantic porgy, *Archosargus probatocephalus*. To help minimize confusion and fix geographical area we, as does AFS, add the attributive. The hyphen disappears on the ground that it was more of a nuisance than a help.

Trichiuridae—cutlassfishes

Pacific cutlassfish .... *Trichiurus nitens* Garman

Scombridae—mackerels and tunas

Wahoo † .... *Acanthocybium solanderi* (Cuvier)

Bullet mackerel .... *Auxis* sp.

Frigate mackerel * .... *Auxis thazard* (Lacepede)

Black skipjack .... *Euthynnus lineatus* Kishinouye

Wavyback skipjack * .... *Euthynnus yaito* Kishinouye

Skipjack tuna .... *Katsuwonus pelamis* (Linnaeus)
Just "skipjack" in CFG, but this name has also been applied for years to a shad, *Alosa chrysochloris*, found in the Gulf of Mexico and in fresh waters of the Mississippi basin. In AFS, this latter became "skipjack herring" (for which there is precedent) and *Katsuwonus* became "skipjack tuna" (for which again there is precedent). A prime concern of California's was to submerge the old AFS name of "oceanic bonito" which was unacceptable on several grounds. AFS assigns the species to genus *Euthynnus*, a step we are not prepared to take on the basis of present understandings.

Pacific yellowfin tuna .... *Neothunnus macropterus* (Temminck and Schlegel)
AFS lists the yellowfin and bigeye tunas as members of genus *Thunnus*. AFS further considers yellowfin, bigeye, albacore and bluefin as forming world wide species whereas we have considered the appropriate pairs in the Atlantic and Pacific as distinct. We believe that the whole problem of tuna systematics and nomenclature needs careful scrutiny on a world-wide basis; it now seems likely that this will be done during the next two years. Pending the results, we retain the well-established generic names of *Neothunnus* and *Parathunnus* for the yellowfin and bigeye, and retain the specific names we have customarily applied to all four species. Yellowfin appears in AFS as "yellowfin tuna, *Thunnus albacares*."

Pacific bigeye tuna .... *Parathunnus sibi* (Temminck and Schlegel)
"Bigeye tuna, *T. obesus*" in AFS. See comment under Pacific yellowfin tuna.

Pacific mackerel .... *Pneumatophorus diego* (Ayres)
AFS uses *Scomber japonicus*, considering the fish conspecific with the Japanese species and regarding *Pneumatophorus* an invalid genus. We retain *Pneumatophorus* and, for the time, *diego* as a species. A more likely reflection of the true relationship of the Japanese and Pacific mackerels would be *P. j. japonicus* and *P. j. diego*.

Pacific bonito .... *Sarda chiliensis* (Cuvier)
Listed as California bonito, *Sarda lineolata*, in CFG. Godsil (1955) showed it was synonymous with *S. chiliensis*, so a change in the attributive to reflect wide distribution on the North and South American coasts was in order. AFS uses this terminology.

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* Not previously listed.
† Not recorded from California.

Mexican bonito †---------------- *Sarda velox* Meek and Hildebrand

Monterey spanish mackerel------ *Scomberomorus concolor* (Lockington)

Sierra †------------------------ *Scomberomorus sierra* Jordan and Starks

Pacific albacore ---------------- *Thunnus germo* (Lacepede)
T. alalunga in AFS. See comment under Pacific yellowfin tuna.

California bluefin tuna ------ *Thunnus saliens* Jordan and Evermann
"Bluefin tuna, *T. thynnus*" in AFS. See comment under Pacific yellowfin tuna.

Luvaridae—louvars

Louvar *---------------------- *Luvarus imperialis* Rafinesque

Istiophoridae—billfishes

Pacific sailfish *---------------- *Istiophorus greyi* Jordan and Evermann
First recorded from California in 1960.

Black marlin *†------------------ *Makaira indica* (Cuvier)

Blue marlin * †------------------ *Makaira nigricans* Lacepede
Robins and de Sylva (1960) refer the record 692-pound "striped marlin" taken off Balboa, California, in 1931 to this species.

Striped marlin ------------------ *Tetrapturus audax* (Phillipi)
La Monte (1955) showed that *audax* has priority over *mitsukurii*, the specific name long applied to this fish. The generic change is based on the work of Robins and de Sylva (1960).

Shortbill spearfish *------------ *Tetrapturus angustirostris* Tanaka

Xiphiidae—swordfishes

Swordfish----------------------- *Xiphias gladius* Linnaeus

Gobiidae—gobies

Bluespot goby *------------------ *Coryphopterus nicholsi* (Bean)

Longjaw mudsucker ------- *Gillichthys mirabilis* Cooper
Simply "mudsucker" in CFG. The attributive now listed appears both in AFS and Shapovalov *et al.* We conform for the sake of conformity but with no strong conviction that the need exists for the lengthier name.

Bluebanded goby *---------------- *Lythrypnus dalli* (Gilbert)

Zebra goby *--------------------- *Lythrypnus zebra* (Gilbert)

Blind goby *--------------------- *Typhiogobius californiensis* Steindachner

Scorpaenidae—rockfishes

In 1957, Phillips published a review of California rockfishes in which he assigned common names to all our species. Because this was a department publication, these became official so far as California was concerned. Except as noted they agreed with CFG as far as that list went and in all but four cases agree with the subsequent AFS list. All species are included here, even though many will rarely be caught by—much less identified by—California fishermen, so that this publication will include all species for which official names have been designated.

Sculpin ------------------------ *Scorpaena guttata* Girard
AFS uses our alternative name, "California scorpionfish." We prefer "sculpin" because it is so firmly implanted in the vernacular, particularly among commercial fishermen.

Rougheye rockfish--------------- *Sebastodes aleutianus* Jordan and Evermann
AFS adopted "blackthroat rockfish" but we feel "rougheye" is more descriptive. This species was not listed in CFG.

* Not previously listed
† Not recorded from California.

Pacific ocean perch *	*Sebastodes alutus* (Gilbert)
Kelp rockfish	*Sebastodes atrovirens* (Jordan and Gilbert)
Brown rockfish	*Sebastodes auriculatus* (Girard)
Aurora rockfish *	*Sebastodes aurora* (Gilbert)
Silvergray rockfish *	*Sebastodes brevispinis* (Bean)
Gopher rockfish	*Sebastodes carnatus* (Jordan and Gilbert)
Copper rockfish	*Sebastodes caurinus* (Richardson)
Greenspotted rockfish	*Sebastodes chlorostictus* (Jordan and Gilbert)
Black-and-yellow rockfish	*Sebastodes chrysomelas* (Jordan and Gilbert)
Starry rockfish	*Sebastodes constellatus* (Jordan and Gilbert)
Darkblotched rockfish *	*Sebastodes crameri* Jordan

"Blackmouth rockfish" in AFS. Same reaction as above. Not in CFG.

Calico rockfish *	*Sebastodes dalli* (Eigenmann and Beeson)
Splitnose rockfish *	*Sebastodes diploproa* (Gilbert)
Greenstriped rockfish	*Sebastodes elongatus* (Ayres)
Widow rockfish	*Sebastodes entomelas* (Jordan and Gilbert)
Pink rockfish	*Sebastodes eos* (Eigenmann and Eigenmann)
Yellowtail rockfish	*Sebastodes flavidus* Ayres
Bronzespotted rockfish *	*Sebastodes gilli* Eigenmann and Eigenmann
Chilipepper	*Sebastodes goodei* Eigenmann and Eigenmann
Rosethorn rockfish	*Sebastodes helvomaculatus* (Ayres)

"Orange-red rockfish" in CFG. Phillips made the change, which AFS followed.

Squarespot rockfish *	*Sebastodes hopkinsi* Cramer
Shortbelly rockfish *	*Sebastodes jordani* Gilbert
Cow rockfish *	*Sebastodes levis* (Eigenmann and Eigenmann)
Mexican rockfish *	*Sebastodes macdonaldi* (Eigenmann and Beeson)

Coral-red rockfish in Phillips and AFS. This species is now taken in fair quantites by Southern California market fishermen. Because of the poor color and texture of the flesh, it brings a very low price and is sorted out before the catch is sold. It is called Mexican rockfish by marketmen and fishermen alike.

Quillback rockfish	*Sebastodes maliger* (Jordan and Gilbert)
Black rockfish	*Sebastodes melanops* (Girard)
Blackgill rockfish *	*Sebastodes melanostomus* Eigenmann and Eigenmann
Vermilion rockfish	*Sebastodes miniatus* (Jordan and Gilbert)
Blue rockfish	*Sebastodes mystinus* (Jordan and Gilbert)
China rockfish	*Sebastodes nebulosus* (Ayres)
Tiger rockfish	*Sebastodes nigrocinctus* (Ayres)

"Blackbanded rockfish" in CFG. Phillips made the change which AFS followed.

Speckled rockfish	*Sebastodes ovalis* Ayres
Bocaccio	*Sebastodes paucispinis* (Ayres)
Canary rockfish	*Sebastodes pinniger* (Jordan and Gilbert)

"Orange rockfish" in CFG. "Canary" is, however, a well established vernacular which appears in Phillips and AFS.

Redstripe rockfish	*Sebastodes proriger* (Jordan and Gilbert)
Grass rockfish	*Sebastodes rastrelliger* (Jordan and Gilbert)
Swordspine rockfish *	*Sebastodes rhodochloris* (Jordan and Gilbert)
Rosy rockfish	*Sebastodes rosaceus* Jordan and Gilbert
Turkey-red rockfish	*Sebastodes ruberrimus* Cramer

"Tambor" (utilizing a name employed by Italian-extraction fishermen) in CFG; most often "yellowbelly" to sportsmen. "Turkey-red," proposed by Phillips is now taking hold. AFS uses "rasphead" but this is equally descriptive of most rockfishes.

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* Not previously listed.

Flag rockfish — *Sebastodes rubrivinctus* (Jordan and Gilbert)
Stripetail rockfish * — *Sebastodes saxicola* (Gilbert)
Halfbanded rockfish — *Sebastodes semicinctus* Gilbert
Olive rockfish — *Sebastodes serranoides* Eigenmann and Eigenmann
Treefish — *Sebastodes serriceps* (Jordan and Gilbert)
Honeycomb rockfish — *Sebastodes umbrosus* (Jordan and Gilbert)
Whitebelly rockfish — *Sebastodes vexillaris* (Jordan and Gilbert)
Pygmy rockfish * — *Sebastodes wilsoni* Gilbert
Sharpchin rockfish * — *Sebastodes zacentrus* (Gilbert)
Shortspine channel rockfish — *Sebastolobus alascanus* Bean

S. altivelis, which follows, did not appear in CFG. With its inclusion, simple "channel rockfish" for *S. alascanus* is insufficient; hence the added attributive which appears in AFS.

Longspine channel rockfish * — *Sebastolobus altivelis* Gilbert

Triglidae—searobins

Lumptail searobin * — *Prinotus stephanophrys* Lockington

Anoplopomatidae—sablefishes

Sablefish — *Anoplopoma fimbria* (Pallas)

Hexagrammidae—greenlings

Kelp greenling — *Hexagrammos decagrammus* (Pallas)

CFG gave "greenling seatrout" primary listing and authorized "kelp greenling" as an alternative. Here the emphasis is reversed, with the long-range hope of eliminating "greenling seatrout" entirely. This latter name was coined to meet a situation wherein some fishermen called the animal "greenling" but most, in California at least, called it "seatrout." AFS uses our primary name.

Whitespotted greenling * — *Hexagrammos stelleri* Tilesius
Rock greenling — *Hexagrammos superciliosus* (Pallas)
Lingcod — *Ophiodon elongatus* Girard
Painted greenling * — *Oxylebius pictus* Gill

Zaniolepidae—combfishes

Shortspine combfish * — *Zaniolepis frenata* Eigenmann
Longspine combfish * — *Zaniolepis latipinnis* Girard

Cottidae—sculpins

Smoothhead sculpin * — *Artedius lateralis* (Girard)
Rosylip sculpin * — *Ascelichthys rhodorus* Jordan and Gilbert
Wooly sculpin * — *Clinocottus analis* (Girard)
Buffalo sculpin * — *Enophrys bison* (Girard)
Red Irish lord * — *Hemilipidotus hemilipidotus* (Tilesius)
Brown Irish lord * — *Hemilepidotus spinosus* (Ayres)
Pacific staghorn sculpin — *Leptocottus armatus* Girard

"Staghorn sculpin," the old CFG listing, is usually sufficient for local purposes. The longer name is from AFS, in which list also appears the "arctic staghorn sculpin, *Gymnocanthus tricuspis*."

Rosy sculpin * — *Oligocottus rubellio* (Greeley)
Fluffy sculpin * — *Oligocottus snyderi* Greeley
Cabezon — *Scorpaenichthys marmoratus* (Ayres)

Ammodytidae—sand lances

Pacific sand lance * — *Ammodytes hexapterus* Pallas

* Not previously listed.

Clinidae—clinids

Island kelpfish * — *Alloclinus holderi* (Lauderbach)
Orangethroat pikeblenny * — *Chaenopsis alepidota* (Gilbert)
Spotted kelpfish * — *Gibbonsia elegans* (Cooper)
Striped kelpfish * — *Gibbonsia metzi* Hubbs
Giant kelpfish — *Heterostichus rostratus* Girard

Just "kelpfish" in CFG. With the addition of other California clinids (above) the old name is inadequate, and the AFS choice seems apropos.

Sarcastic fringhead * — *Neoclinus blanchardi* Girard
Onespot fringehead * — *Neoclinus uninotatus* Hubbs
Reef finspot * — *Paraclinus integrippinis* (Smith)

Blenniidae—combtooth blennies

Rockpool blenny * — *Hypsoblennius gilberti* (Jordan)

Anarichadidae—wolffishes

Wolf-eel — *Anarrhichthys ocellatus* Ayres

Stichaeidae—pricklebacks

Monkeyface eel — *Cebidichthys violaceus* (Girard)

"Monkeyface blenny" in AFS. We believe you can't fly with success in the face of established usage, and fishermen insist that this is an eel even though it is a blenny.

Rock eel — *Xiphister mucosus* (Girard)

"Rock blenny" in AFS. Same comment as above.

Stromateidae—butterfishes

Medusafish * — *Icichthys lockingtoni* Jordan and Gilbert
Pacific pompano — *Palometa simillima* (Ayres)

Tetragonuridae—squaretails

Smalleye squaretail * — *Tetragonurus cuvieri* Risso

Sphyraenidae—barracudas

California barracuda — *Sphyraena argentea* (Girard)

"Pacific barracuda" in AFS. It is, however, largely confined to the Californias (Alta and Baja). Further, another species replaces it in southern Baja California and the Gulf of California.

Mugilidae—mullets

Striped mullet — *Mugil cephalus* Linnaeus

Atherinidae—silversides

Topsmelt — *Atherinops affinis* (Ayres)
Jacksmelt — *Atherinopsis californiensis* Girard
Gulf grunion * † — *Leuresthes sardina* (Jenkins and Evermann)
California grunion — *Leuresthes tenuis* (Ayres)

ORDER PLEURONECTIFORMES

Bothidae—lefteye flounders

Pacific sanddab — *Citharichthys sordidus* (Girard)
Speckled sanddab — *Citharichthys stigmaeus* Jordan and Gilbert
Longfin sanddab — *Citharichthys xanthostigma* Gilbert
Bigmouth sole — *Hippoglossina stomata* Eigenmann and Eigenmann
California halibut — *Paralichthys californicus* (Ayres)
Fantail sole — *Xystreurys liolepis* Jordan and Gilbert

* Not previously listed.
† Not recorded from California.

Pleuronectidae—righteye flounders

Arrowtooth flounder ____________ *Atheresthes stomias* (Jordan and Gilbert)
"Arrowtooth halibut" in CFG; "arrowtooth sole" in the 1948 AFS list. Now AFS has changed to "flounder" better to reflect Canadian usage. The fish is not particularly important in California; commercial fisherman here generally call it "turbot."

Deepsea sole ____________________ *Embassichthys bathybius* (Gilbert)

Petrale sole ____________________ *Eopsetta jordani* (Lockington)

Rex sole ______________________ *Glyptocephalus zachirus* Lockington

Pacific halibut _________________ *Hippoglossus stenolepis* Schmidt

Diamond turbot _______________ *Hypsopsetta guttulata* (Girard)

Scaly-fin sole __________________ *Isopsetta isolepis* (Lockington)
"Butter sole" in AFS. That name is established particularly in Canada.

Rock sole _____________________ *Lepidopsetta bilineata* (Ayres)

Slender sole ___________________ *Lyopsetta exilis* (Jordan and Gilbert)

Dover sole ____________________ *Microstomus pacificus* (Lockington)

English sole ___________________ *Parophrys vetulus* Girard

Starry flounder ________________ *Platichthys stellatus* (Pallas)

C-O turbot _____________________ *Pleuronichthys coenosus* Girard
"Sole" in AFS. Members of this genus are generally called "turbot" and lumped under that name in reporting the California commercial catch. For that reason we retain "turbot."

Curlfin turbot _________________ *Pleuronichthys decurrens* Jordan and Gilbert
See the comment above.

Spotted turbot ________________ *Pleuronichthys ritteri* Starks and Morris

Hornyhead turbot ______________ *Pleuronichthys verticalis* Jordan and Gilbert

Sand sole _____________________ *Psettichthys melanostictus* Girard

Cynoglossidae—tonguefishes

California tonguefish __________ *Symphurus atricauda* (Jordan and Gilbert)

ORDER ECHENEIFORMES

Echeneidae—remoras

Remora ________________________ *Remora remora* (Linnaeus)
We have dropped the attributive "common" (CFG) in conformance with AFS policy.

ORDER TETRAODONTIFORMES

Balistidae—triggerfishes and filefishes

Finescale triggerfish * __________ *Balistes polylepis* Steindachner

Molidae—molas

Mola __________________________ *Mola mola* (Linnaeus)
We retain "mola" as short and distinctive; AFS adopted "ocean sunfish" which is also applied to this species in the vernacular.

ORDER BATRACHOIDIFORMES

Batrachoididae—toadfishes

Slim midshipman _______________ *Porichthys myriaster* Hubbs and Schultz

Northern midshipman ___________ *Porichthys notatus* Girard
The common names for these two species leave much to be desired because the adjectives do not describe either shape or distribution. The two can be separated readily at any age by the speckling on the membranes of the dorsal and pectoral fins of *myriaster*. In *notatus* no such speckling occurs. We propose as alternative names "specklefin midshipman" for *myriaster* and "plainfin midshipman" for *notatus*.

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* Not previously listed.

REFERENCES

American Fisheries Society

1948. A list of common and scientific names of the better known fishes of the United States and Canada. Amer. Fish. Soc., Spec. Publ. 1, 45 pp.

1960. A list of common and scientific names of fishes from the United States and Canada. 2nd ed. Amer. Fish. Soc., Spec. Publ. 2, 102 pp.

Berdegue, A. Julio

1956. Peces de importancia commercial en la costa nor-occidental de Mexico. Sec. de Marina, Mexico, 345 pp.

Bigelow, Henry B., and William C. Schroeder

1948. Fishes of the Western North Atlantic. Chap. 3. Sharks. Sears Found. Mar. Res., Mem. 1, Pt. 1, pp. 59-576.

1953. Fishes of the Western North Atlantic. Chap. 1. Sawfishes, guitarfishes, skates and rays. Sears Found. Mar. Res., Mem. 1, Pt. 2, pp. 1-514.

Garrick, J. A. F.

1960. Studies on New Zealand Elasmobranchii. Pt. 10. The genus *Echinorhinus*, with an account of a second species, *E. cookei* Pietschmann, 1928, from New Zealand waters. Roy. Soc. New Zealand, Trans., vol. 88, pt. 1, pp. 105-117.

Godsil, H. C.

1955. A description of two species of bonito *Sarda orientalis* and *S. chiliensis* and a consideration of relationships within the genus. Calif. Dept. Fish and Game, Fish Bull. 99, 43 pp.

Ishiyama, Reizo

1958. Studies on the rajid fishes (Rajidae) found in the waters around Japan. Shimenoseki Coll. Fish., Jour., vol. 7, no. 2, 3, pp. 193-394.

La Monte, Francesca

1955. A review and revision of the marlins, genus *Makaira*. Amer. Mus. Nat. Hist., Bull. 107, Pt. 3, pp. 323-358.

Phillips, J. B.

1957. A review of the rockfishes of California (family Scorpaenidae). Calif. Dept. Fish and Game, Fish Bull. 104, 158 pp.

Robins, C. Richard, and Donald P. deSylva

1960. Descriptions and relationships of the longbill spearfish, *Tetrapturus belone*, based on western North Atlantic specimens. Bull. Mar. Sci. Gulf and Carib., vol. 10, no. 4, pp. 383-413.

Roedel, Phil M.

1953. Official common names of certain marine fishes of California. Calif. Fish and Game, vol. 39, no. 2, pp. 251-262.

Shapovalov, Leo, and William A. Dill

1950. A check list of the fresh-water and anadromous fishes of California. Calif. Fish and Game, Vol. 36, no. 4, pp. 382-391.

Shapovalov, Leo, William A. Dill, and Almo J. Cordone

1959. A revised check list of the freshwater and anadromous fishes of California. Calif. Fish and Game, vol. 45, no. 3, pp. 159-180.

Walters, Vladimir, and John E. Fitch

1960. The families and genera of the lampridiform (allotriognath) suborder Trachipteroidei. Calif. Fish and Game, vol. 46, no. 4, pp. 441-451.

THE PISMO CLAM IN 1960[1]

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The 1960 Pismo clam census was conducted by Marine Resources Operations biologists from December 16 to 19 at Morro Bay and Pismo Beach. The regular sections, Morro, Pismo, Oceano and Le Grande were sampled (Baxter, 1961).

Three clams were dug in the Morro section and were 1, 7, and 18 years old (Table 1). Only the oldest was of a legal size (4½ inches diameter). The set of young clams at Morro Bay was practically nil for the sixteenth consecutive year. Censuses have been taken in this area since 1949 and these data show that the last good set occurred in 1944. Whether there were extended periods of unsuccessful spawning prior to the early 1940's is not known. Discounting a small 1952 year-class the longest period of "drouth" at Pismo Beach (since 1919) was 10 years.

The three, six-inch-wide trenches at Pismo Beach yielded 188 clams (Table 1), but only seven were over three years old. Five of the seven were legal sized and were 8 to 26 years old; the two undersized clams were 5 and 15 years old. There were good numbers of one-, two- and three-year-old clams on the northern end of the beach. The survival of the 1957, 1958 and 1959 year-classes was not as good as some year-classes of the 1930's and 1940's but seemingly guarantees at least moderately good digging in the near future.

The 1960 set of young clams on Pismo Beach was only fair compared to those of the three previous years, except on the south end of the beach (Le Grande section) where it exceeded any set since 1946. The set in this area may have been better than indicated since the section was continually inundated during censusing. Undoubtedly a number of zero clams were lost because complete screening of the sand was not possible under such adverse conditions. Therefore, the 32 zero clams recorded represent a minimal figure.

DISCUSSION

At present, the digger at Pismo Beach must get much wetter and spend more time than he did in past years to be successful. Harvestable clams are becoming more scarce each year and cannot be expected to continue yielding significant numbers for much longer under the heavy clamming pressure to which they are continually subjected. Fortunately in 1961, increasing numbers of the 1957 year-class will attain legal size followed each succeeding year by the 1958, 1959 and 1960 year-classes. Good clamming will undoubtedly depend upon harvesting

[1] Submitted for publication May 1961.

TABLE 1

Number of Clams by Year-Class Taken in the One Morro Bay and Three Pismo Beach Sections in 1960

Section	Year-Class and Age											
	1960 0	1959 I	1958 II	1957 III	1956 IV	1955 V	1954 VI	1953 VII	1952 VIII	1951 IX	1950+ X+	Total
Morro	0	1	0	0	0	0	0	1	0	0	1	3
Pismo	7	25	17	14	0	1	0	0	1	0	0	65
Oceano	10	34	14	17	0	0	0	0	0	0	3	78
Le Grande	32	7	3	1	0	0	0	0	0	0	2	45
Morro Bay Total	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**1**	**3**
Pismo Beach Total	**49**	**66**	**34**	**32**	**0**	**1**	**0**	**0**	**1**	**0**	**5**	**188**

the animals as they attain legal size, thus emphasizing the importance of reburying undersized clams lest they wash up on the beach to perish in the sun. Unless the beaches are blessed with a super-abundant year-class in the near future, the only hope for continued good clamming would appear to be a succession of good sets with at least average survival. The four moderate year-classes now coming on undoubtedly will be harvested as soon as they are large enough. If a long period of poor recruitment, such as experienced during the 10 years prior to 1957, should occur, it is doubtful that the present population would be abundant enough to support a healthy fishery through such a period.

At Morro Bay the situation is extremely serious. The clam population is drastically reduced and will not continue in significant numbers much longer. With no sizeable incoming year-classes there is every indication that good digging along the stretch of beach north of Morro Rock soon will become only a pleasant memory. Since it takes a minimum of seven years for clams in this area to reach legal size and much longer for the bulk of them to do so, the digger will have to reconcile himself to an extended period of virtually no return for his efforts.

REFERENCE

Baxter, John L.
1961. Results of the 1955 to 1959 Pismo clam censuses. Calif. Fish and Game, vol. 47, no. 2, pp. 151-162.

AGE DETERMINATION OF THE PACIFIC ALBACORE OF THE CALIFORNIA COAST[1]

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INTRODUCTION

For over two decades investigators have explored methods of determining the age of albacore, *Thunnus germo* (Lacépède).

Vertebral centra first were used to estimate age by Uno (1936); his lead was followed by Aikawa and Katō (1938), Partlo (1955), and by Otsu and Uchida (1959) who examined both vertebrae and scales.

Nose, *et al.* (1955) based their work on caudal peduncle scales from the vicinity of the fourth and sixth dorsal finlets. Otsu and Uchida (1959) examined scales below the second dorsal fin. They discontinued this work because of the "undetermined nature of scale formation and only about one-half were considered readable".

Past albacore age determinations do not agree in the age-length relationship, and the calculated growth rates cannot be correlated with information developed through tagging (Clemens, 1961).

Aging albacore by using vertebral centra showed little promise and this method was abandoned early in the present investigation; continuous vertebrae sampling for age determination of the commercial catch was impractical as it involved dissecting valuable market fish. Routine aging is needed for each season's catch and a method which would not reduce the value of the sampled fish was required.

Before searching for some new anatomical structure which might indicate chronological age, it seemed worthwhile to try the scale method for aging albacore since, in our judgment, it had neither been properly confirmed nor repudiated. Albacore scales present unique problems, but no one had exhausted the possibilities this structure afforded.

This paper reports the methods used and results of a study to determine the age of albacore in the California fishery. The ages have been correlated with the length distribution modes of the commercial catch and with the growth rates demonstrated by tagging. With these data we plan to determine the age composition of the California commercial catch and establish a basis with which to examine year-class strength.

METHODS

Most albacore scales are thick, blistered, and impregnated with oil. The circuli are obscure on the anterior trunk scales and on those as far posterior as the second dorsal fin. Scales were examined from the entire body surface, and the most suitable were from the caudal peduncle.

[1] Submitted for publication July 1961.

FIGURE 1. Photomicrograph of scale from 581 mm albacore. One annulus near the anterior scale radius is clear.
Photographed with an Exacta mounted on a Zeiss stereomicroscope; 1/50 sec., mag. 40 x; film Kodachrome, KA 135-balanced for flood; lighting incident tungsten, no filters. Photograph by *R. R. Bell.*

Those in the vicinity of the fifth dorsal finlet were free from oil and blistering and had clear circuli and checks suggesting annular formation (Figures 1, 2, 3, and 4); therefore, our samples were obtained from a ¾-inch area below the fifth dorsal finlet on the left side of the fish. The largest and most symmetrical scales were selected from a sample of 30 or 40 from each fish. These were cleaned and dry-mounted between glass slides and projected on a screen prepared with grid lines and an index. At 100 diameters a projected scale could be read directly to the nearest .01 mm. Attempts to obtain a constant image size to avoid subjectivity in reading were discontinued as the number of circuli and the scale character seldom failed to provide evidence of the fish size. We could make a good approximation of the fish length by looking at the projected scale regardless of the image size. Eight scales were examined from each fish, to reduce the possibility of reading false checks as annuli. Checks were considered valid if they appeared on all scales. The most readable scale from each series of eight was measured and back calculations of fish lengths at annulus formation were made. In a subsample of 31 albacore, scales taken from the caudal peduncle and from below the second dorsal fin had similar characteristics. Back calculations from the two samples were comparable but not in exact

FIGURE 2. Photomicrograph of scale from 694 mm albacore. Two annuli can be seen. Photographed with an Exacta mounted on a Zeiss stereomicroscope; 1/50 sec., mag. 25 x; film Ektachrome, EH 135-20, Type F; lighting incident tungsten, no filters. Photograph by *R. R. Bell.*

agreement; the larger dorsal scales gave higher values for back calculated lengths in many cases.

Seventy-two (18 percent) of the 396 scale samples could not be read because they were regenerated, did not exhibit checks, or had so many that the annuli could not be distinguished.

Two types of sampling were conducted—a stratified scale sample for age determination and a random sample of lengths to determine the frequency composition of the catch. The random sample of the catch consisted of 50 fish from each vessel in port. When landings were heavy not all vessels could be sampled, but a concerted effort was made to sample as many as possible. The stratified sample insured that all size classes would be included in the scale collection.

All lengths were measured in millimeters, from the tip of the upper jaw or snout to the fork of the tail, with calipers. Weights were recorded in the stratified sample to the nearest quarter pound. The name and Department of Fish and Game number of the vessel making the catch, the area in which the catch was made, and the date of the landing were recorded.

Collection of scales began in September 1959 and continued to the abrupt conclusion of the season in the second week of November.

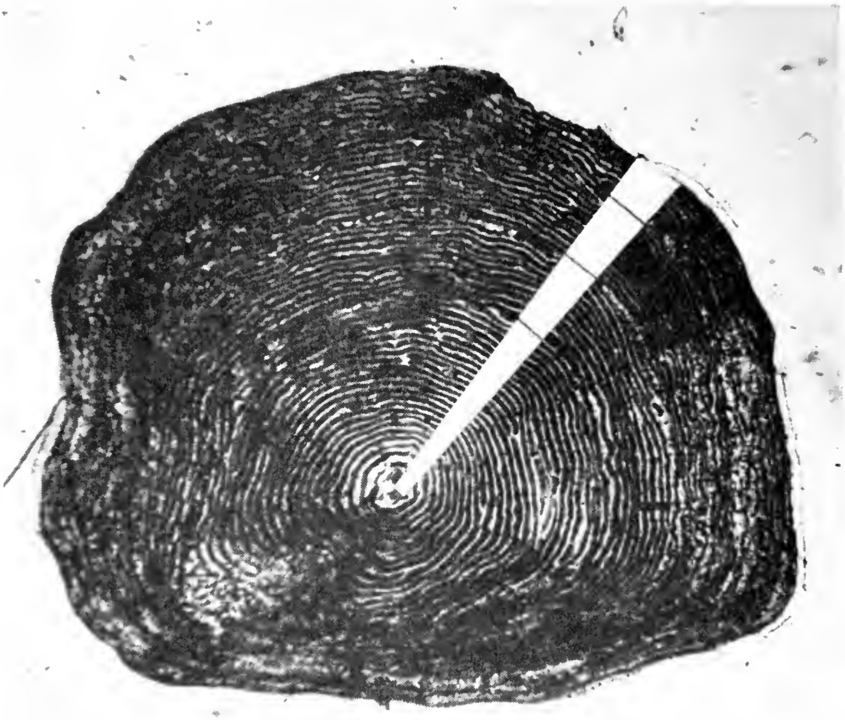

FIGURE 3. Photomicrograph of scale from 750 mm albacore. Three annuli can be distinguished. Photographed with an Exacta maunted on a Zeiss stereomicroscope; 1/100 sec., mag. 25 x; film Plus X Pan 135; lighting incident tungsten, no filters. Photograph by *A. V. Vogel.*

Lengths, weights and scales were recorded from the stratified sample of 396 albacore. The majority of the samples was collected at San Pedro although 47 were from San Francisco.

Scales were collected from two fish in each centimeter-class during each week of the three-month period. The midpoints in the classes were multiples of 10 millimeters; for example, the 65 cm class had a midpoint of 650 mm and a range of 645 to 655 mm. Fork lengths of albacore from the length frequency samples ranged from 51 to 98 cm resulting in 48 classes; however, some contained few fish. The extremes of the range were inadequately represented for an aging study in the samples taken from the random length distribution. There was too little material to properly assign ages to the largest or smallest fish or to assess correctly the age composition of a particular centimeter-class at the range extremes. On the average, however, eight scale samples for each centimeter-class were available each month to establish the age composition.

RESULTS

Diagnosing annuli necessitated considering several features. An annulus was distinguished by crowding of circuli, discontinuous circuli, and transparent areas as reported by Nose, *et al.* (1955) who stated,

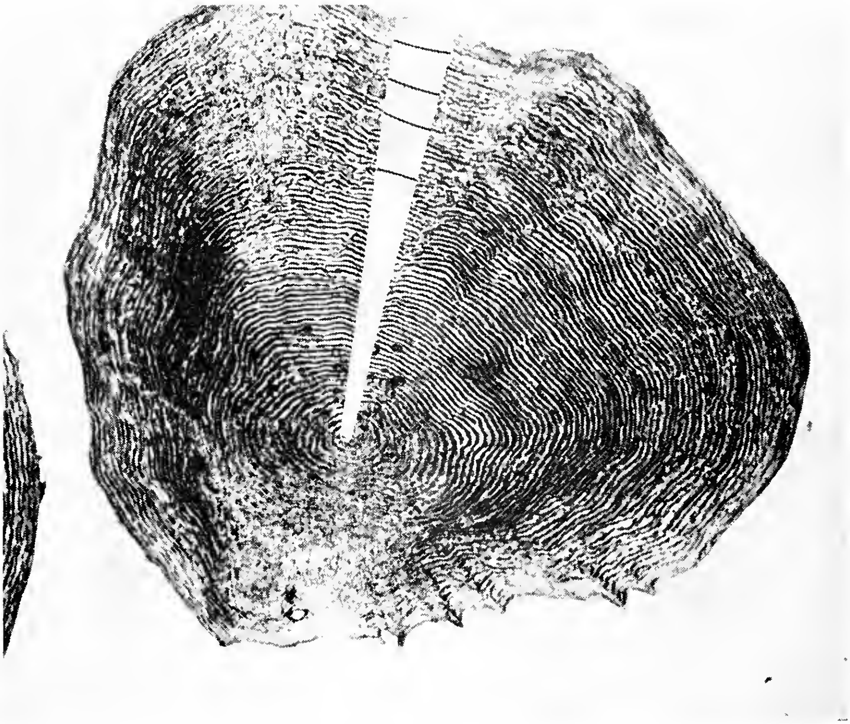

FIGURE 4. Photomicragroph of a scale from an 828 mm albacore. Four annuli can be distinguished.
Photograph by Medical Illustration Service, V.A. Hospital, Long Beach.

"The ring (annulus) appears as a transparent line, nearby which the circuli become fine and discontinuous . . .".

Scales from small fish were relatively easy to read, while those from fish longer than 900 mm fork length, were more difficult. Scales from fish between 700 and 800 mm long were troublesome. In most cases the first annulus was found about 0.92 mm and the second about 1.20 mm from the focus.

Two factors assisted us to understand the significance of the checks and aided in decisions to designate certain of them as annuli. These were the abundance of small specimens in the samples and the availability of growth data (Clemens, 1961). Many of the former attempts to age albacore were made using large fish; however, the California catch provides an abundance of relatively small fish, thus permitting an examination of scales progressing from small fish, which are least difficult to age, to the large ones with their more obscure and difficult-to-interpret scale sculpturing.

The percentage of fish in the catch by length was superimposed on the age groups in order to examine the relationship between the two variables (Figure 5). The length frequency distribution is fairly typical of the California catch in recent years with the exception that the 774 mm mode, which is indicated by scale reading as a year-class, does not appear in the length frequency distribution portion of the

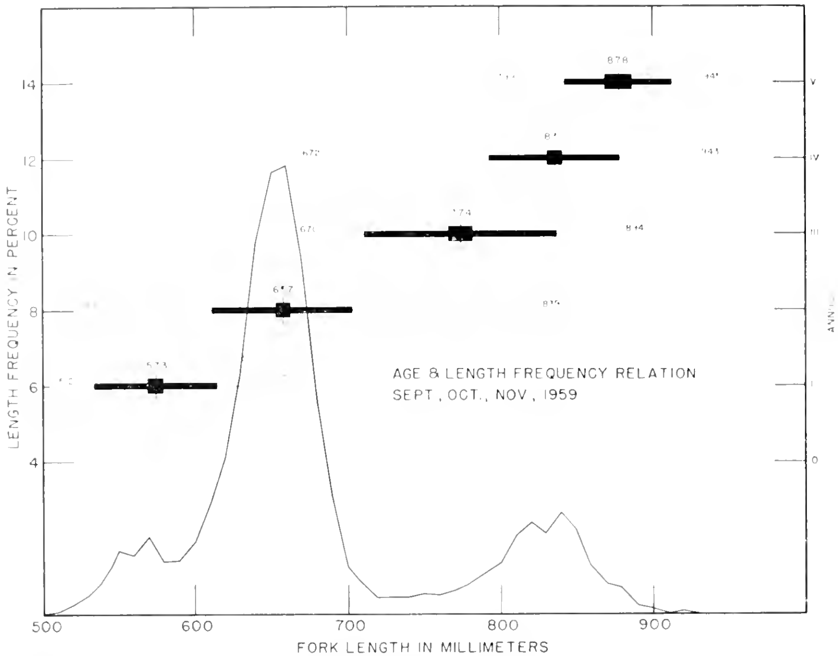

FIGURE 5. Age and length frequency relationship of sampled albacore. The fine line represents the range; the long solid box, one standard deviation on either side of the mean; and the short box, one standard error of the mean on either side of the mean.

graph. However, it does appear prominently in the length frequency distributions of the past 40 years. There is good agreement between the modal lengths and the mean lengths of the assigned age groups.

The results of this study have been summarized for the three months of the investigation (Table 1). From the stratified sample of 396 scale samples, 324 were read and assigned to age groups. Mean length, standard deviation, and standard error of the mean were calculated for each group.

Early in the investigation it was hypothesized that the fleet captured only the largest fish of the first modal group. The mean distance from the focus to the annulus of age group I fish compared with the distance

TABLE 1
Ages of 324 Albacore Captured in the Eastern Pacific, September Through November 1959

Age group	I	II	III	IV	V
Number	68	113	64	63	16
Mean length (mm)	573	657	774	837	878
Standard deviation	38.2	47.1	61.2	42.6	33.6
Standard error of the mean	4.6	4.4	7.6	5.4	8.4
Range (mm)	512 664	530 839	670 894	672 943	799 945

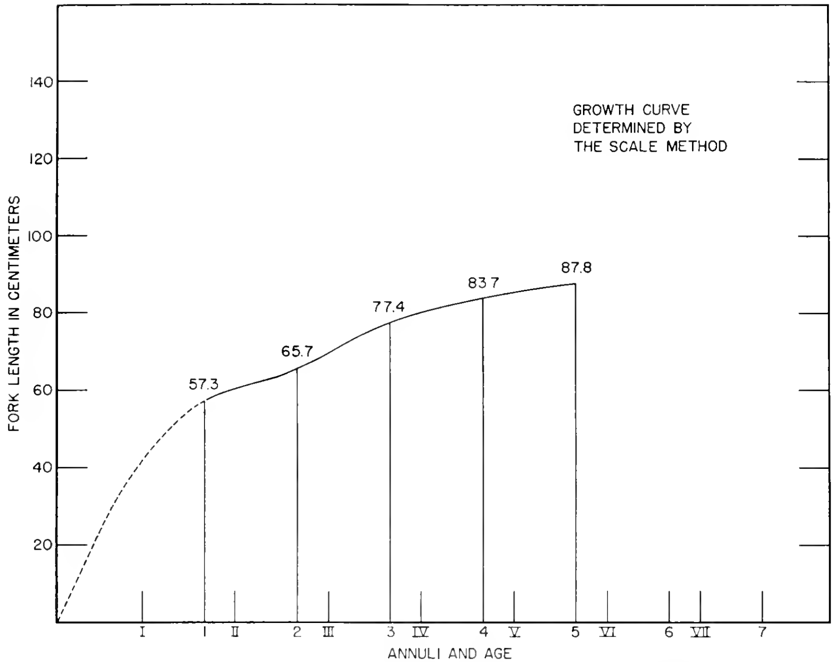

FIGURE 6. Albacore growth curve. The scale of the abscissa represents months of the year. The first annulus is set hypothetically at February. The age is set at October. The intercept at y is set at March.

to the first annulus in age groups II, III, IV and V, plus the discrepancy in growth increments and the resulting anomalus growth curve substantiate the hypothesis (Figure 6). In a subsample, the mean distance from the focus to the first annulus was as follows:

I	*II*	*III*	*IV*
1.02 mm	0.90 mm	0.90 mm	0.96 mm

The average growth rate, determined by examining the scales, was 7.6 cm per year (Table 2). The apparent slow growth rate between the

TABLE 2
Average Albacore Length Increment for Age Groups I Through V

Age group	Mean Length (cm)	Increment (cm/year)
I	57.3	
		8.4
II	65.7	
		11.7
III	77.4	
		6.3
IV	83.7	
		4.1
V	87.8	

first- and second-year fish is the result of the commercial catch failing to reflect the true position of the first mode of the population.

The albacore length-age data obtained from scale aging were fitted to the von Bertalanffy growth equation. The results based on length at time of capture are as follows:

Age	Empirical data (mm)	Fitted growth (mm) von Bertalanffy equation
I	573	564.62
II	657	669.90
III	774	754.00
IV	837	821.18
V	878	874.85

The equation used and the parameters are:

$$l_t = L_\infty \left[1 - e^{-K(t-t_0)}\right]$$

$$L_\infty = 1087.9648$$

$$K = .2247$$

$$t_0 = -2.2728$$

The present work reveals a more rapid growth rate for albacore than has been calculated by previous investigators. Otsu (1960) computed the slowest rate of the several estimates prepared by Uno (1936), Aikawa and Katō (1938), Partlo (1955), and Nose *et al.* (1955).

The first mode which appeared in the California catch (560 mm) consisted of fish in their second year of life. Thus the mean length of the first-mode (one-year-old) fish, presumably in early spring, would be about 495 mm (determined by back calculation of the annulus). During the winter, albacore smaller than this length should have no annulus. One albacore 381 mm fork length was available for examination; it had been collected near Guadalupe Island on December 7, 1957. There were no checks on its scales.

The albacore is generally considered a slow-growing fish compared with other tunas. Few fishes exceed the yellowfin tuna in speed of growth. Blunt and Messersmith (1960) found eastern Pacific yellowfin tuna grew as much as 420 mm in length (35 pounds) in a year. Moore (1951) reported central Pacific yellowfin tuna grew as much as 60 pounds in one year (1,245 to 1,524 mm approximately). One yellowfin tuna tagged at 570 mm grew to 1,338 mm in 842 days (Blunt and Messersmith, 1960). Clemens (1961) reported the growth of albacore was over six pounds in one year. As an individual moved from the first modal group (560 mm) to the second (670 mm) the weight was almost doubled. An analysis of length frequency data (Clemens, 1961) demonstrated that the modes in the commercial catch represent age groups. Furthermore, the progression of dominant year-classes has been traced through the yearly progression of modes by Clemens (unpublished).

SUMMARY

1. Readable albacore scales were found in the vicinity of the fifth dorsal finlet.

2. Three hundred and ninety-six scale samples were collected from albacore caught in the California commercial fishery during September, October, and November 1959.

3. The smallest group of fish entering the California commercial catch (573 mm) are in their second year of life. Fish in their third year of life averaged 657 mm long and the fish in their fourth year were 774 mm. Albacore in their fifth year had a mean length of 837 mm. The oldest fish were six years old and averaged 878 mm long.

ACKNOWLEDGMENTS

A number of people have made important contributions to this research. The writer wishes, in particular, to acknowledge the work of Harold B. Clemens, who hypothesized rapid albacore growth rates and suggested this approach to determine their ages. The writer is indebted to Jack D. Linn for his excellent field collections and to Patrick K. Tomlinson for technical assistance.

REFERENCES

Aikawa, Hiroaki, and Masuo Katō
1938. Age determination of fish (preliminary report 1). Jap. Soc. Sci. Fish., Bull., vol. 7, no. 1, pp. 79-88. Translated from the Japanese by W. G. Van Campen.

Blunt, Clarkson E., and James D. Messersmith
1960. Tuna tagging in the eastern tropical Pacific 1952-1959. Calif. Fish and Game, vol. 46, no. 3, pp. 301-369.

Clemens, Harold B.
1955. Catch localities for Pacific albacore *(Thunnus germo)* landed in California, 1951 through 1953. Calif. Dept. Fish and Game, Fish Bull., no. 100, 28 pp.
1961. Migration, age and growth of the Pacific albacore. Calif. Dept. Fish and Game. Fish Bull., no. 115, 128 pp.

Moore, Harvey L.
1951. Estimation of age and growth of yellowfin tuna *(Neothunnus macropterus)* in Hawaiian waters by size frequencies. U.S. Fish and Wildl. Serv., Fish. Bull., vol. 52, no. 65, pp. 133-149.

Nose, Yukio, *et al.*
1955. A method to determine the time of ring-formation in hard tissues of fishes, especially for the age determination of Pacific tunas. Rec. Oceanog. Works in Japan, vol. 2, no. 3, n.s., pp. 9-18.

Otsu, Tamio, and Richard N. Uchida
1959. Study of age determination by hard parts of albacore from central North Pacific and Hawaiian waters. U.S. Fish and Wildl. Serv., Fish. Bull., vol. 59, no. 150, pp. 353-363.

Otsu, Tamio
1960. Albacore migration and growth in the North Pacific Ocean. Pac. Sci., vol. 14, no. 3, pp. 257-266.

Partlo, J. M.
1955. Distribution, age and growth of eastern Pacific albacore *(Thunnus alalunga Gmelin)*. Fish Res. Bd. Canada. Jour., vol. 12, pp. 35-60.

Uno, Michio
1936a. *Germo germo* (Lacépède) in the waters east of Nozima Promontory, Tiba Prefecture (preliminary report 2). Jap. Soc. Sci. Fish., Bull., vol. 4, no. 5, pp. 307-309.

1936b. *Germo germo* (Lacépède) in the waters east of Nozima Promontory, Tiba Prefecture (preliminary report 2). Jap. Soc. Sci. Fish., Bull., vol. 5, no. 4, p. 235.

MANIPULATION OF SHRUB FORM AND BROWSE PRODUCTION IN GAME RANGE IMPROVEMENT[1]

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INTRODUCTION

Browse plants, like forage grasses, are variable in vigor, form, and productivity. Unfortunately, less is known about these attributes in the woody plants than in the herbaceous ones. We do know, however, that certain species which are considered good browse on deer ranges show great plasticity in form, great variation in vigor, and marked differences in production of digestible material. It remains to be learned how these characteristics are associated and under what conditions their optimums can be obtained. In other words, what can be done to produce the most browse on a deer range?

The following conditions are known to affect the shape, life expectancy, and productivity of a shrub:

1. The immediate environment: depth and fertility of soil, available moisture and sunlight, etc.
2. The density and distribution of shrubs and other kinds of plants in a stand, and the competition between them.
3. The browsing "schedule"; this includes the stage in the life history of the plant when browsed, the periodicity of browsing, the intensity of browsing (degree of utilization), the duration of rest, and perhaps other factors.

These factors are not completely independent of each other. But the important point is that they can be changed by various kinds of manipulation. Management of a brush range for deer, then, involves selection of those changes that will lead to more browse production. Therefore, a knowledge of the effects of any manipulation is essential.

Manipulation of the environment, chiefly through changing the soil fertility level, has been tried. While it has not been determined whether such practice would be economically feasible on deer ranges, there can be no doubt that brush plants, especially seedlings, respond to fertilization and irrigation (Schultz, Biswell, and Vlamis, 1958). Fertilized seedlings are much larger and more vigorous than nonfertilized seedlings.

Shade from taller plants and competition with herbaceous vegetation for nutrients and soil moisture result in mortality of some brush seedlings and stunted growth in those which survive (Schultz, Launchbaugh,

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[1] Submitted for publication May, 1961. This study is part of a project conducted by the University of California under contract with the California Department of Fish and Game under Federal Aid in Wildlife Restoration Act Project W-51-R, "Big Game Investigations."

and Biswell, 1955). Depending on the management objective, competition can either be intensified, for example, by grass fertilization (Gartner, Schultz, and Biswell, 1957), or decreased by selective spraying or grazing.

Density and distribution of young brush plants alone, whether there is competition from other kinds of plants or not, determine the growth form these plants take on as they mature. The same principle applies to the "wolf" tree and the self-pruned trees of a densely-stocked forest.

This paper deals only with the effect of the browsing factor on growth form and forage production of shrubs. Soil fertility, plant density, and competition are also involved, to be sure, but as direct factors they were either uncontrolled or unmeasured in our experimental approach to the problem. As indirect factors, they are very important. For example, soil fertility may determine the population level of the deer herd. Plants growing in close proximity can offer a nearly impassable barrier to browsing animals. Mechanical means and fire have been effectively used in opening up and thinning such stands (Biswell *et al.*, 1952).

A number of studies have been made to assess the effect of different intensities of use on browse plants. The effects of browsing, simulated by clipping, have been studied by Julander (1937), Young and Payne (1948), Aldous (1952), and Garrison (1953). Mature, established plants were used in most of the experiments. Aldous' study included young trees. In general the response to browsing varied greatly among species, with light to moderate clipping stimulating many shrubs to greater vegetative growth. Removal of most of the current growth over a period of years usually caused a decline in production and vigor, and was often fatal to plants. Flower and seed production was suppressed under even moderate use intensities. Selection of any "best" use intensity appears to require an intimate knowledge of the species involved and the season of use.

Plant stature greatly affects the browse supplies. Plants that grow above the "browse line"—the height to which deer normally reach (about 4.5 feet)—produce little available browse. This condition is often encountered in mature stands of mixed chaparral with a large component of inherently tall, rapidly growing species. Manipulation of such brush stands to place the plants in an available state is a necessary step in increasing browse production. Since the growth of young plants can be greatly influenced by browsing, this study was designed to determine the effect of changes in the "periodicity" and intensity of browsing following manipulation of a mature stand of mixed chaparral.

METHOD OF STUDY

The study was conducted on the San Joaquin deer winter range located on the west side of the Sierra Nevada in Madera County, California. This winter range lies between 2,000 and 5,000 feet elevation on the west side of the San Joaquin River canyon. Topography is rough, ranging from precipitous slopes to level benches. Areas of deer concentration are primarily confined to the benches, ridgetops, and adjacent slopes. Annual precipitation is about 34 inches. Part of this is in the form of snow, but during the six-year study period the ground was rarely covered for more than a few days at a time. Vegetation includes ponderosa pine forest, oak woodland, and extensive areas of mixed chaparral. The study plots were located on a fairly level ridge-top at an elevation of about 3,500 feet. Prior to the study a dense, mature stand of mixed chaparral occupied this site.

In 1954 a brush manipulation program was started on the winter range. The purpose of the program was to increase the supply of browse by manipulating the chaparral, most of which was so tall or dense that it was largely unavailable to deer. The brush was mashed with a bulldozer and then burned early in the spring of 1955. Since the original cover contained both sprouting and nonsprouting brush species, the treatment resulted in a mixed stand of sprouts and seedlings.

To assess the effect of browsing intensity on the developing plants, a series of exclosures was established to simulate deer herd reduction. The exclosures were patterned after the "exclusion transects" used by Sarvis (1923). Two plots were laid out on the manipulated area, each 180 x 100 feet, and divided into three parts. One plot was completely fenced in the fall of the first season (1955) following manipulation. This exclosure will be referred to as exclosure I. The other plot, henceforth called exclosure II, was left open. In succeeding years, one third of exclosure I was opened and one third of exclosure II was enclosed. Thus, when the study ended in the fall of 1960, exclosure I had received the following treatments, in sequence from first to last year: one year of protection, four years of browsing; two years of protection, three years of browsing; three years of protection, two years of browsing. Exclosure II had the reverse of the above treatments: three years of browsing, one year of protection, one year of browsing; two years of browsing, two years of protection, one year of browsing; one year of browsing, three years of protection, one year of browsing (see base of Figure 1). The

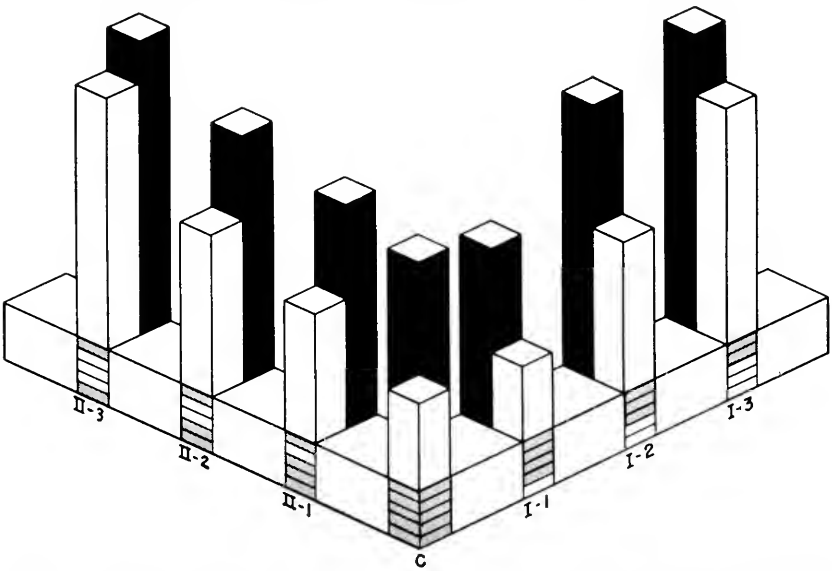

FIGURE 1. Average heights after six seasons of growth for wedgeleaf ceanothus seedlings (white columns) and chaparral whitethorn seedlings (black columns); n = 100 and 50 seedlings, respectively. The bricks under the columns, read in sequence from bottom to top, denote treatment. Grey signifies a year of browsing, white a year of protection. Height of the continuously browsed wedgeleaf ceanothus seedling (C) is 15.6 inches.

relatively small size of the exclosures and the variable species composition restricted sampling. But it was possible to observe, and in some cases to measure objectively, response of the important browse species.

Areas not protected were browsed heavily by deer from November to May each year. Pellet counts made each spring on the unprotected area indicated 100 to 140 deer days of use per acre every winter. Utilization checks carried out in conjunction with other studies showed that 50 to 80 percent, by weight, of the current growth of preferred browse species was removed each winter. During April, May, and June, cattle used the area.

RESPONSE OF SPROUTING SPECIES

Two important sprouting species, western mountain mahogany (*Cercocarpus betuloides*) and flannel bush (*Fremontia californica*), were represented in all treatments. Both species are highly preferred as browse and are vigorous sprouters. Flannel bush sprouts grew rapidly

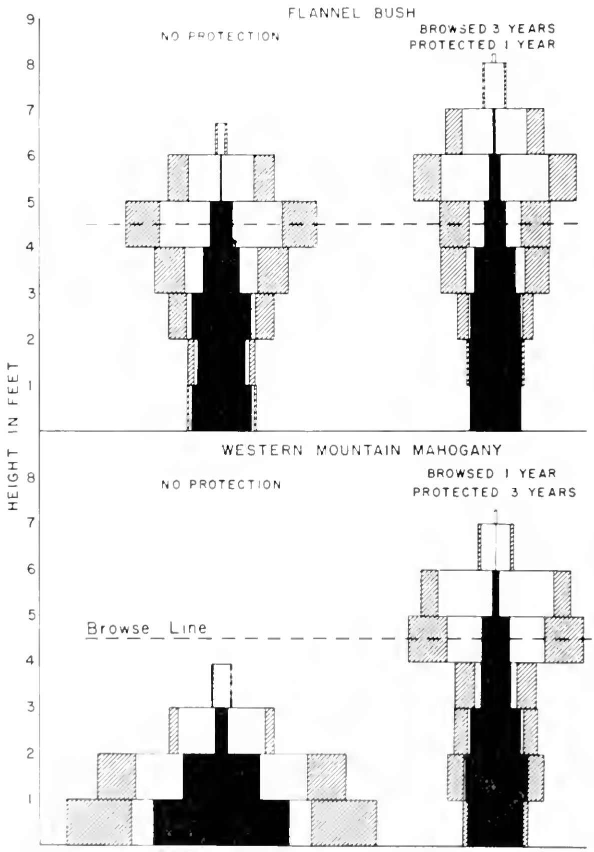

FIGURE 2. Effect of different browsing treatments on growth form of shrubs. Proportion by weight, in each 1-foot segment of leaves (grey), current twig growth (white), and old stem (black), each component calculated separately. For example, about 65 percent of leaves, 50 percent of new leaders, and 95 percent of old growth occur below browse line on continuously browsed flannel bush.

and, even under continuous browsing, were growing out of reach of the deer when the study was terminated at the end of the sixth growing season. There were no discernible differences among sprouts receiving one, two, or three years of protection. A single year of protection enabled them to reach heights at which most of the current growth was unavailable to deer (Figure 2). Heights of plants within the exclosures ranged from 8 to 10 feet at the end of the sixth growing season.

Under continuous browsing, few western mountain mahogany sprouts grew above the browse line during the study period. This species grows more slowly than flannel bush, and deer consume a larger portion of the current twigs, greatly reducing the cumulative increase in height. Although the number of plants which had "escaped", by growing above the browse line, was small, many were at heights where a single favorable growing season would place a number of stems out of reach. Sprouts receiving only one year of protection were not significantly different from those with no protection. But when the plants were protected for two and three years, heights of 6 to 8 feet were attained by the end of the sixth growing season. On the taller sprouts, most of the current production was unavailable to deer (Figure 2). As with flannel bush, the lowest portions of the tall plants had only a few, short current twigs. Near the base, leaves were borne mainly on short spurs instead of on long, new twigs as was the case on the upper portion of the sprouts.

Other browse species were represented by a few sprouts in one or more treatments. Honeysuckle (*Lonicera interrupta*) sprouts grew rapidly when protected, but the lax stems were browsed heavily by deer when the exclosures were opened. Redberry (*Rhamnus crocea* var. *ilicifolia*) sprouts grew above the browse line only if protected for two or more years.

The cattle which used the area each spring had a marked influence on the height of the sprouts. Stems above the deer browse line produce new leaves early in the spring, before many leaves form on the lower twigs. In attempting to reach this lush, new growth, cattle pulled down and broke the taller stems, and often consumed the terminal portions. This "topping" effect was widespread on flannel bush sprouts (Figure 3). It also occurred on the tall mountain mahogany sprouts when the exclosures were opened. Plants that were not taller than the browse line also received some use, but the results were not so spectacular.

Due to the rapid growth of sprouts, especially those of flannel bush, heavy browsing is necessary if they are to be maintained in an available form. With light browsing the plants may be more vigorous, but they soon grow into a largely unavailable form.

RESPONSE OF BRUSH SEEDLINGS

Three nonsprouting browse species were on the experimental area: Wedgeleaf ceanothus (*Ceanothus cuneatus*), chaparral whitethorn (*C. leucodermis*) (this species does sprout to some extent), and Mariposa manzanita (*Arctostaphylos mariposa*). Seedlings of wedgeleaf ceanothus and chaparral whitethorn, both highly preferred as browse, appeared in large numbers in the spring of 1955 and 1956. Mariposa manzanita, a poor browse species, was much less abundant. Survival rates on the different treatments could not be determined because local site and competition differences masked any differences among treatments. Counts made in exclosure I showed a seedling density of 1.8 per square foot in the spring of 1956. When the study was terminated the stand was still very dense—0.6 seedlings per sq. ft.

A number of ceanothus seedlings which germinated in the spring of 1955 were tagged in exclosure I, and the heights were recorded each spring and fall. Wedgeleaf ceanothus seedlings that were browsed continuously and those protected for only one year made very little growth in height after the second season. Seedlings protected for two and three years made rapid upward growth while protected but, as the exclosures were opened, browsing caused a reduction in height and sharply curtailed further gains. Chaparral whitethorn seedlings were able to make small but steady gains in height under continuous browsing. This species grows more rapidly than wedgeleaf ceanothus, and develops thorn-like twigs which deter browsing animals.

By the fall of 1960, significant height differences in the ceanothus seedlings still prevailed among the treatments within exclosures (Figure 1). At that time all seedlings had been browsed following protection, with six full seasons of growth. Continuously browsed wedgeleaf ceanothus seedlings were taller than those protected the first year. When

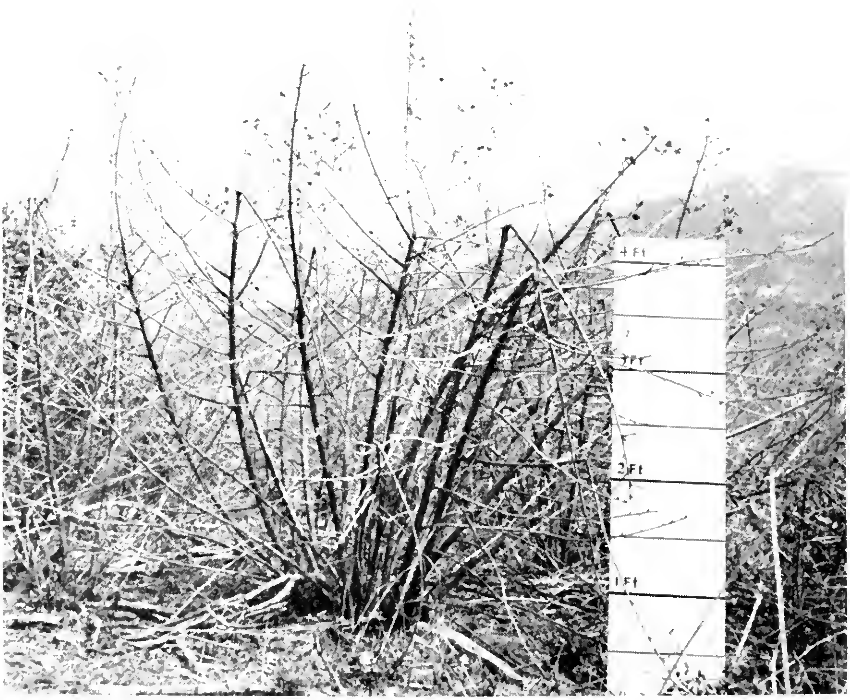

FIGURE 3. Flannel bush sprout which was protected for three years and browsed two years. The main stems have been broken off or bent down by cattle, effectively "topping" the sprout. Picture was taken in the spring after deer had stripped off practically all leaves within reach.

protection came in the fourth year (II-1), seedlings were taller than when protection came in the first year (I-1). No such between-exclosure differences occurred with added years of protection. Chaparral whitethorn seedlings with one year of protection after browsing (II-1) were taller than those with one year of protection before browsing (I-1). However, seedlings with two years of protection before browsing (I-2) were taller than those with a corresponding period of protection after browsing (II-2). Seedlings protected for three years did not differ.

Mariposa manzanita seedlings were much smaller in stature than the ceanothus seedlings, but displayed similar treatment differences. The population was too sparse to permit between-exclosure comparisons.

The total weight of wedgeleaf ceanothus seedlings was determined by clipping and weighing six plants of average height from each treatment in the fall of 1960. Total weight was closely correlated with height, and a graphical presentation of weights would appear much like that shown for heights in Figure 1. The major difference between height and weight comparisons was that seedlings with one year of protection were not significantly heavier than those browsed continuously although they were significantly taller.

The increase in size of the plants with two or more years of protection was evident in diameter as well as in height and weight. Hence, the crown cover of shrubs was much higher on protected areas (Figure 4). Larger amounts of litter and mulch accumulated where the herbaceous vegetation was not grazed by deer and cattle.

FIGURE 4. Area occupied by chaparral whitethorn seedlings after four growing seasons. Area to left of fence was browsed each year while area on right was protected.

It is difficult to determine, from the evidence at hand, which was the "best" treatment for ceanothus. Three years of protection allowed the plants to attain heights from which they could readily escape the deer, and this would be desirable if seed production is the aim. Under continuous browsing, or with one year of protection, the plants would be in an available form for a long time but continuation of the heavy browsing might cause excessive mortality. Plants protected for only two years probably approach a more nearly optimum condition in size and vigor.

UTILIZATION BY DEER

The utilization of shrubs is usually expressed as the percent of weight or volume of current growth removed during a given period. However, the season of use and the composition of the material removed, in terms of leaves, leaders, and buds, are better criteria than weight in judging the effect of browsing. Since all of the shrubs exhibit apical dominance, the fate of the terminal bud is especially important. Removal of the apical buds of chamise (*Adenostoma fasciculatum*,) was found to cause twigs to respond in one of the following ways: reproductive axillary growth, vegetative axillary growth, enlargement of leaves, and no response (Bedell and Heady, 1959). All of these responses have the common characteristic of inhibiting upward growth. Subsequent twig growth from axillary buds leads to a compound twig arrangement and, if apical buds are removed for several successive years, an interwoven mass of branches develops. Thus, if apical buds are removed each year, plants may be maintained in a short, available, "hedged" form.

During the fall of 1958, 50 leaders (10 per plant) of wedgeleaf ceanothus and chaparral whitethorn were tagged and measured in exclosure 1. Measurement of the same leaders in the spring showed that 94 and 83 percent of the terminal buds were destroyed on wedgeleaf ceanothus and chaparral whitethorn, respectively. The reduction in leader length on individual plants ranged from 1 to 37 percent. In the fall of 1959, the tagging operation was carried out for all treatments, and Mariposa manzanita seedlings were included. During the following winter, 98 percent of the terminal buds on wedgeleaf ceanothus were bitten off. On chaparral whitethorn, 84 percent of the terminal buds were destroyed, with most of those remaining degenerating into a thorn-like structure. Reduction in leader length ranged from 5 to 66 percent. Mariposa manzanita, which develops relatively few branches, lost 98 percent of the terminal buds.

If reduction in leader length is used as an index, utilization of wedgeleaf ceanothus was 17 percent in 1958-59 and 31 percent in 1959-60. Even though only about half as much was browsed from the leaders in 1958-59, apical dominance was nearly completely removed in both winters. The heavier use undoubtedly affects plant vigor, but has little more effect on the form of the plants than does the lighter level of use.

Comparison of the amount removed from the tagged leaders of seedlings and sprouts on the various treatments failed to show a consistent preference by deer for plants which had been protected. Measurement of the leaders in December, 1959, did show that the lush growth of plants protected the previous season was more attractive to deer early in winter than were plants that had been browsed during the previous season. By spring, the difference in use had nearly disappeared. It is felt that other factors, such as position in relation to escape cover and associated species, influenced the degree of utilization more than did mere abundance of succulent growth.

DISCUSSION

When dealing with long-lived woody plants it is difficult to extrapolate data from a short period of observation. Since the investigations were terminated after only six years, the ultimate effect of the exclosures on the form and productivity of the plants was not determined. We can, on the basis of production data obtained, say that at this time the treatment in which the plants were protected for two years appears best. Under this treatment, wedgeleaf ceanothus seedlings were vigorous and tall enough so that some plants would soon escape the deer and thereby provide seed production. Although many of the sprouts had escaped and chaparral whitehorn seedlings would soon follow, it is felt that management should favor the abundant wedgeleaf ceanothus plants, which offer the greatest browse production potential on this particular area.

To aid in the interpretation of the data, examples of the results of past use were sought on other portions of the winter range. Of particular interest was an area burned by wildfire in 1939. The wildfire

FIGURE 5. A 22-year-old western mountain mahogany sprout which has largely grown out of reach of deer despite heavy utilization. Only a few heavily hedged stems at the base of the plant produce available browse.

affected the vegetation in much the same manner as the mashing and burning treatment, since a stand of ceanothus seedlings and sprouts of various species appeared after the fire. Today this Source Point burn, as it is called, is a good example of what can result from 22 years of use by deer during the winter months and livestock in summer.

There are large numbers of western mountain mahogany and flannel bush plants on the area, which originated from old root crowns as sprouts. Only a small portion of these plants has the low, rounded form which is wholly available to deer. The more common form of the plants is illustrated in Figure 5. A few stems which grew out of reach became dominant and produced a tree-like form which has been pruned or "highlined" by deer. Usually there is a cluster of short, hedged stems around the base, which produce some available browse. Flannel bush plants have escaped more completely than those of western mountain mahogany. It seems that, even under a prolonged period of intensive use, the sprouts of both species become largely unavailable.

We can assume that the sprouts of these two species on the continuous browsing treatment will soon have a form similar to the one in Figure 5. As shown by the rapid growth of protected sprouts, any period of light browsing serves only to hasten the escape, especially if operative when the sprouts are young and vigorous. The evidence indicates that sprouts of flannel bush and western mountain mahogany must be very heavily used to keep them in an available, productive form for any length of time.

FIGURE 6. A stand of 22-year-old wedgeleaf ceanothus plants which are all hedged into a "basket" shape. Areas such as this are very productive in terms of available browse.

The wedgeleaf ceanothus plants on the Source Point burn give an indication of what those on the continuous browsing treatment will look like in 15 years (Figure 6). The plants are almost all hedged into a "basket" shape. This form is nearly ideal from the standpoint of browse production. The rounded shape presents a large "surface" from which new twigs arise, and the tightly interwoven stems provide protection for a portion of the leaves. Disregarding other factors for the moment, we can envision an area producing the maximum amount of available browse as one populated entirely with plants in this form. The intensity of use which has produced this condition on the Source Point area has been excessive as evidenced by the number of dead and dying plants. However, many plants appear to be high in vigor, and may survive for many years. Judging from the fate of terminal buds on plants in the exclosures, basket forms might be maintained under more moderate use.

An area containing only heavily hedged ceanothus plants is vulnerable to the agent which caused the brush seeds to germinate—fire. The plants produce few, if any, seeds and should a wildfire sweep the area, would be killed and the population thus wiped out. Ample evidence of this is furnished by a small portion of the original burn which was reburned by another wildfire. All of the ceanothus plants were killed, and only grass remains on a formerly productive brush site. When dealing with nonsprouting species, a seed supply is essential to insure perpetuation of the range resource, especially where fires are likely to occur.

FIGURE 7. A wedgeleaf ceanothus plant with a "Mae West" shape. Lower branches produce browse while the stems which have grown out of reach of deer produce seed.

Chaparral whitethorn plants were able to attain mature size under heavy use. Most of the plants have grown above the browse line and produce seed. Browse production, of course, is less than when the plants had a basket shape.

To fulfill the dual requirements of sustained browse yield and adequate seed production, a mixture of plant forms is necessary. Some plants need to be allowed to grow above the browse line but others must be kept in a hedged, available form. This condition may be achieved by a single plant form, colloquially called the "Mae West" shape (Figure 7.). The hedged lower portion supplies browse while the central stems which have grown out of reach produce seed. Since ceanothus plants distribute seeds over a fairly large area, the number of escaped plants need not be large. The exclosures indicate that it would take only a short period of light use to develop such plants.

The mixture of sprouting and nonsprouting species on chaparral ranges makes the regulation of browsing difficult since different intensities of use are necessary to produce available forms in the two kinds of plants. Sprouting species on the Source Point burn indicate a need for more intensive use to maintain available forms. However, greater concentrations of deer during the winter months might be disastrous to other aspects of the range. Large numbers of animals trampling wet soils can cause severe erosion (Figure 8). The deeply cut trails, gullies, and generally accelerated erosion on the Source Point burn indicate that deer numbers have been too high. Under such conditions the reduc-

FIGURE 8. Wet soil loosened by trampling of deer will be washed away by next rain. Such trampling can cause serious gullying of erosive soils.

tion in water infiltration and soil fertility due to erosion may have as much influence on the growth and survival of plants as browsing.

Regulation of the deer herd through hunting will provide some measure of control over browsing and trampling of manipulated areas during the winter months. Reduced browsing pressure would allow the escape of some ceanothus plants but would also allow most sprouts to escape. However, the "topping" effect observed on the study area could furnish an effective way of slowing the upward growth and prolonging the period of sprout availability. Livestock may be controlled far more easily than deer populations, and a more precise level of browsing pressure applied. Although primarily grazers, cattle will take appreciable amounts of browse during the dry forage season. If special provisions were made for the development of wedgeleaf ceanothus seed plants, a higher level of use would be possible. For example, small wire exclosures might be used to protect either whole plants or merely a few stems in the center of a bush. If browse production is seriously lowered by escaping sprouts, they can be remashed with a bulldozer. Burning cannot be repeated at frequent intervals where ceanothus plants are important, but sprouting species will sprout well without burning.

Browsing pressure is an important factor affecting the form of plants, but density is also important as it may affect form independent of use levels. With 0.6 seedling per sq. ft. on the exclosure plots, the stand is too dense for sustained browse production. When plants growing so close together increase in size browsing animals are obstructed, resulting in reduction of browsing and unhindered upward growth. This will result in a stand similar to the one shown in Figure 9. Such stands

FIGURE 9. A dense, tall stand of wedgeleaf ceanothus such as develops when the plants are growing close together. Very little available browse is produced, and browsing animals are physically obstructed. Heavy shade limits development of understory vegetation.

are obviously not desirable sources of browse even though seed production is high. Also, herbaceous vegetation, an important item in deer diet, does not grow under the dense shrub canopy.

Plant density may be controlled in several ways. The time of burning will influence seedling numbers and survival, with fall burns producing denser stands. Grasses may be seeded to provide competition and increase seedling mortality. The level of competition may be decreased by selective grazing by livestock or increased by fertilization. Grasses will provide a measure of erosion control as well as competition and forage. Selective spraying or cutting could also be used in reducing plant density. Such measures would be necessary for sprouts because they are not very susceptible to competition from grasses. Through manipulation of density, what has been termed "shrubland" (Taber, 1956) may be obtained—low, rounded bushes interspersed by grasses and herbaceous vegetation. On deer winter ranges, the distance between shrubs should be only enough to provide free access; on ranges where cattle are the more important users, the distance can be increased.

Close attention should be given to the species composition on particular sites when manipulating the factors affecting plant form and density. The variation among species in the amount of browsing pressure required to maintain vigorous, available forms necessitates close regulation of browsing at a level which will give best overall production on a particular site. Site evaluation before initial manipulation of cover can also point to areas where grasses need to be sown to reduce brush seedling density, provide erosion control, and furnish a wider variety of forage. Fertilizers might also be used to advantage on depleted soils to insure an adequate crop of seedlings and promote growth. Judging from the response of the plants in the rotating exclosures, manipulation of factors early in the life cycle will have the greatest effect.

SUMMARY

1. The effect of different periods of protection on the form and production of browse plants was studied on a deer winter range in Madera County, California. The study plots were established following manipulation, by mashing and burning, of an area of mature, mixed chaparral. Important sprouting browse plants were western mountain mahogany and flannel bush. Nonsprouting species, represented by large numbers of seedlings, were wedgeleaf ceanothus and chaparral whitethorn. Two rotating exclosures were used to provide one, two, and three years of protection preceding browsing in one exclosure, and following like periods of browsing in the other exclosure. Observations were carried out from 1955 to 1960.

2. Sprouting species grew rapidly following manipulation, and a single year of protection allowed them to escape the deer. Continuous use appeared to be the best treatment for sprouts because they were thus maintained in an available form for a longer period of time.

3. Wedgeleaf ceanothus seedlings protected for only one year and those browsed continuously made little growth in height after the second season. Seedlings protected for two and three years made rapid growth until exclosures were opened to browsing. After six growing

seasons significant height differences still prevailed among treatments within exclosures. The only difference between protection periods preceding and following browsing occurred with one year of protection. Chaparral whitethorn seedlings were larger than wedgeleaf ceanothus in all treatments, and were able to make consistent gains in height under continuous browsing. Two years of protection appeared to be the best treatment for wedgeleaf ceanothus, and continuous browsing seemed best for chaparral whitethorn.

4. Utilization checks showed that 98, 94 and 98 percent, respectively, of the terminal buds on wedgeleaf ceanothus, chaparral whitethorn, and Mariposa manzanita seedlings were destroyed by browsing although reduction in leader length on individual plants ranged from 5 to 66 percent. This indicates that available forms may be maintained under moderate use.

5. Plants of western mountain mahogany and flannel bush on a 22-year-old wildfire burn indicated that these species will develop a tree-like, largely unavailable form even under long periods of heavy use. Wedgeleaf ceanothus plants on the wildfire burn were nearly all in an available, "basket" form. This form produces maximum amounts of browse, but not the seed which is a necessary insurance against recurring wildfires.

6. Browsing pressure greatly influences the form of plants, and through manipulation of this factor, desirable forms may be maintained. Plant density also affects the form of plants and may manipulated by cultural and grazing practices. Cattle might be used to provide greater flexibility and control of browsing and grazing pressure.

LITERATURE CITED

Aldous, Shaler E.
1952. Deer browse clipping study in the Lake States region. J. Wildl. Mangt., vol. 16, no. 4, pp. 401-409.

Bedell, Thomas E., and Harold F. Heady
1959. Rate of twig elongation of chamise. J. Range Mangt., vol. 12, no. 3, pp. 116-121.

Biswell, H. H., R. D. Taber, D. W. Hedrick, and A. M. Schultz
1952. Management of chamise brushlands for game in the north coast region of California. Calif. Fish and Game, vol. 38, no. 4, pp. 453-484.

Garrison, George A.
1953. Effects of clipping on some range shrubs. J. Range Mangt., vol. 6, no. 5, pp. 309-317.

Gartner, F. R., A. M. Schultz, and H. H. Biswell
1957. Ryegrass and brush seedling competition for nitrogen on two soil types. J. Range Mangt., vol. 10, no. 5, pp. 213-220.

Julander, Odell
1937. Utilization of browse by wildlife. Trans. North Am. Wildl. Conf., vol. 2, pp. 276-287.

Sarvis, J. T.
1923. Effects of different systems and intensities of grazing upon the native vegetation at the northern Great Plains field station. U.S.D.A. Bull. no. 1170. 45 pp.

Schultz, A. M., H. H. Biswell, and J. Vlamis
1958. Responses of brush seedlings to fertilizers. Calif. Fish and Game, vol. 44, no. 4, pp. 335-348.

Schultz, A. M., J. L. Launchbaugh, and H. H. Biswell
1955. Relationship between grass density and brush seedling survival. Ecology, vol. 36, no. 2, pp. 228-238.

Taber, Richard D.
1956. Deer nutrition and population dynamics in the north coast range of California. Trans. North Am. Wildl. Conf., vol. 21, pp. 159-172.

Young, V. A., and Gene F. Payne
1948. Utilization of "key" browse species in relation to proper grazing practices in cutover western white pine lands in northern Idaho. Jour. For., vol. 46, no. 1, pp. 35-40.

IMPORTANCE OF NORTHWEST COASTAL CALIFORNIA TO WATERFOWL[1]

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INTRODUCTION

The purpose of this study was to determine how important the immediate coastal areas of northern California are to some of the populations of waterfowl in the Pacific Flyway as described by Lincoln (1939).

Very little information has been published on the importance of the immediate coastal areas of California, Oregon, and Washington to waterfowl. Banding by Munro (1943, 1944) in British Columbia was restricted primarily to mallards (*Anas platyrhynchos*) and pintails (*Anas acuta*), and most of the mallards wintered in the coastal plains of British Columbia and northwestern Washington. Pintails remain in that area only in mild winters (Munro, 1943). Most of the data on migrations of waterfowl published up to 1950 in British Columbia, Washington, and Oregon are summarized by Yocom (1951).

Offshore migrations in the Pacific Ocean have been observed and recorded by several people (Lincoln, 1939; Gabrielson and Jewett, 1940; Yocom, 1947). Hansen and Nelson (1957) believe that black brant (*Branta nigricans*) fly southeast from the tip of the Alaska Peninsula at Cold Bay, crossing the open ocean south of Kodiak Island. Probably birds on these flights stay well off the coast, at least as far south as Puget Sound, and others remain offshore until they reach coastal California. We have observed fall flocks of black brant passing south offshore of the Humboldt Bay area, and none of these particular birds had come inland to pass over the bay.

Most of the studies on waterfowl migrating through western Washington and British Columbia since 1950 have not been published. Lauckhart (1956) calculated mortality rates on mallards banded in the Yakima Valley and the Skagit River Delta, Washington. This study, however, does not include data on migration.

Breeding and wintering populations of waterfowl were studied and a number of birds were banded over a period of years to determine how important Humboldt Bay is to migrating birds.

THE AREA

Humboldt and Del Norte counties are located over 200 miles north of San Francisco on the northwest coast of California. Both counties are extremely mountainous and timbered for the most part (Yocom and

[1] Submitted for publication June, 1961.

Dasmann, 1957). Little habitat is available for most species of waterfowl except for Humboldt Bay, the coastal flood plains of several rivers, and a few freshwater lagoons, which are separated from the Pacific Ocean by sandbars (Figure 1).

Humboldt Bay is over 200 nautical miles north of San Francisco Bay and approximately 180 nautical miles south of Coos Bay, Oregon. This 14 mile long bay which covers 24.5 square miles at high tide and 7.8 square miles at low tide (Anonymous, 1955) is described by Yocom and Keller (1961); the ecology of the area near the Bay and inland from the coast is described by Yocom and Dasmann (1957).

Other important bodies of water along the coast are: Big Lagoon, 1,470 acres; Stone Lagoon, 521 acres; Freshwater Lagoon, 245 acres; Lake Earl, approximately 3,000 acres; and Lake Talawa, between 500

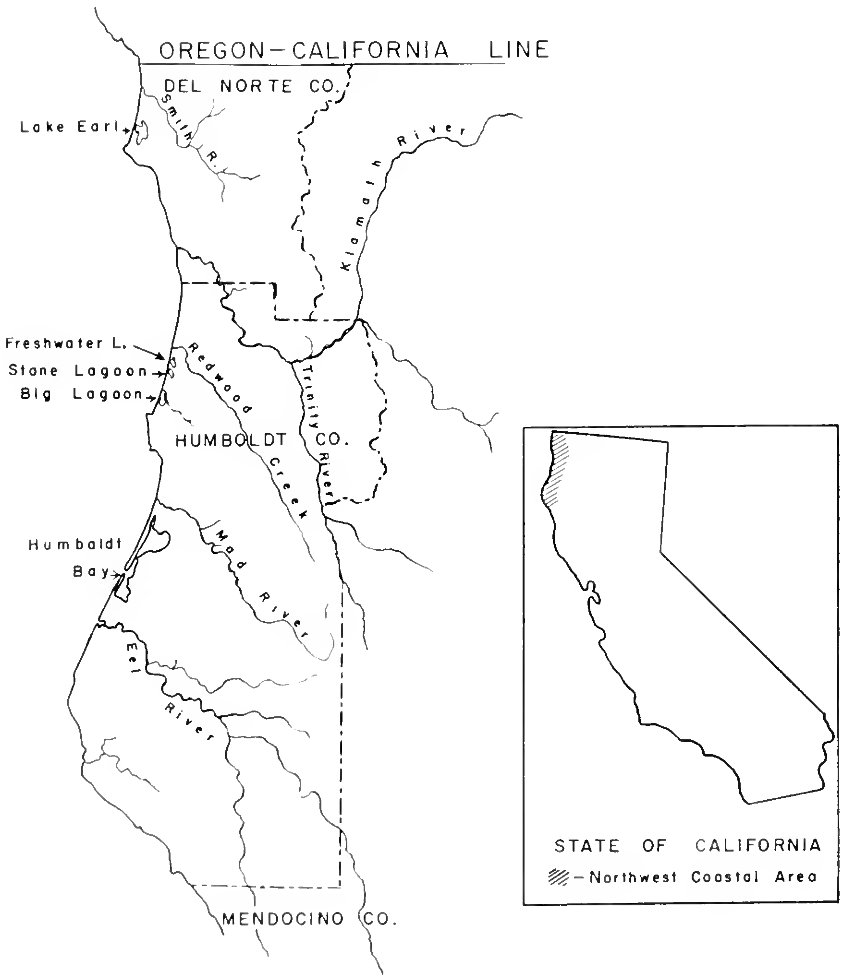


FIGURE 1. Northwest coastal area of California showing counties, major rivers, bays, lakes and lagoons.

and 600 acres. The lagoons, including Lake Talawa, do not support large volumes of waterfowl food plants; however, Lake Earl produces much *Potamogeton pectinatus* and considerable amounts of other aquatic plants including *Scirpus acutus, S. americanus, Eleocharis macrostachya,* etc. Large numbers of divers including canvasbacks and redheads are known to use this lake.

WINTERING POPULATIONS

Munro (1957) published observations on winter waterfowl populations at Morro Bay, California. Widgeons (*Mareca americana*) often were present in larger numbers than all other species of waterfowl seen on the Bay at any one time. Pintails were second in number. Large numbers of black brant used Morro Bay.

Studies by Yocom and Keller (1961) on the food habits of waterfowl wintering in Humboldt Bay, California, show that widgeons and black brant probably are the most common species wintering in this area because of the abundant supply of eel grass (*Zostera marina*). Pintails were the third most abundant species using Humboldt Bay followed by several other species (Table I).

Other species of waterfowl frequenting the northwest coastal area of California include whistling swan (*Olor columbianus*) which use the Eel River Bottoms as a wintering area each year. A large subspecies of Canada goose that may be *Branta canadensis fulva* winters in the vicinity of Lake Earl, Del Norte County, and is occasionally seen in the Eel River and Humboldt Bay areas. Flocks of cackling Canada geese (*Branta canadensis minima*), lesser Canada geese (*Branta canadensis parvipes*), white-fronted geese (*Anser albifrons frontalis*) and lesser snow geese (*Chen hyperborea hyperborea*) have been seen in this coastal area each fall usually during the month of October. Apparently these flocks fly down the coast to this area where many of them turn inland and fly over the coastal mountains to the great valleys of California where they winter. We have few records for these species in the spring months. One American brant (*Branta bernicla hrota*) was collected on Humboldt Bay in 1958 (Murrell, 1959). An emperor goose (*Philacte canagica*) taken in Humboldt County in 1945 is in the Humboldt State College collection. Between December 31, 1957 and January 4, 1958 from one to five emperor geese were seen in Crescent City harbor, Del Norte County. Grinnell and Miller (1944) refer to other records in this area.

Ducks occasionally seen in this area include American golden-eyes (*Bucephala clangula americana*), American scoters (*Oidemia niger americana*), harlequin ducks (*Histrionicus histrionicus*), and European widgeons (*Mareca penelope*). American mergansers (*Mergus merganser americanus*) are common on coastal streams, and red-breasted mergansers (*Mergus serrator serrator*) are seen frequently in the coastal bays and lagoons.

The United States Fish and Wildlife Service estimated that over 124,000 ducks were present on Humboldt Bay at the time of the 1955 winter inventory; of these, 67,200 were widgeon. Bentley and Christianson (1957) estimated that there were 57,000 ducks and 37,000 black brant present during the winter of 1957. Denson noted that approximately 35,000 brant spent March and April on South Humboldt Bay during 1960 and 1961. It should be pointed out that these figures presumably represent wintering ducks and the northward migrating brant. It was impossible to determine whether there was constant egress and replacement of waterfowl. Undoubtedly, large numbers of birds pass through the area spending from a few hours to several days on the bay during fall and spring migrations.

TABLE 1

Relative Abundance of Waterfowl From October 16, 1956-April 15, 1957, Humboldt Bay, Humboldt County, California

Species	*Percent of total*
Widgeon	47.2
Black Brant	20.3
Pintail	15.6
Canvasback	4.2
Coot	2.7
Scaup (Greater and Lesser)	2.5
Bufflehead	0.7
Redhead	0.6
Green-winged Teal	0.4
Mallard	0.3
Shoveler	0.3
Whistling Swan	0.2
Scoter (3 species)	0.1
Ruddy Duck	0.1
Gadwall	trace
Canada Goose	trace
Unidentified	4.8

Calculated from aerial inventories in 1956-57 by Bentley and Christianson (1957).

BREEDING WATERFOWL

The northwest coast of California is not an extensive nesting area for waterfowl because the mountains extend to the sea in many areas leaving limited waterfowl habitats (Yocom and Dasmann, 1957); however, mallards commonly nest in the coastal habitats including marshes, lagoons, river deltas, and the Humboldt Bay area. They also nest near inland ponds and streams which are often many miles from the coast.

Wood ducks (*Aix sponsa*) nest near the marshes, lakes and streams in the wooded area of Humboldt and Del Norte counties (Naylor, 1960).

Cinnamon teal (*Anas cyanoptera*) were known to have nested in the Arcata bottoms in 1951 (Dollahite and Anderson, 1952). We have several recent records of broods seen in the Arcata bottoms and in the marshes northwest of Lake Earl, Del Norte County, which indicates that the breeding population of cinnamon teal may be increasing in these areas. Thirteen males were seen in one flock on the Arcata bottoms on June 11, 1960.

Blue-winged teal (*Anas discors*) apparently nest in the Lake Earl-Talawa Lake area of Del Norte County (Yocom and Wooten, 1956). On June 7, 1960, two males in partial eclipse plumage were seen by Stanley Harris and Yocom in the Lake Earl area. A pair of blue-winged teal was seen on June 11, 1960, in the Arcata bottoms by Yocom. We have several records for the months of April and May, but we assume these represent migrants.

Shovelers were first found breeding in the Arcata bottoms in June, 1960 (Yocom, 1961). American mergansers breed along the larger mountain streams in both Del Norte and Humboldt counties. Adult male gadwalls (*Anas strepera*) and a mated pair have been seen in the Lake Earl area in June which indicates that they may nest in that area.

A pintail nest was found on the sand spit near South Humboldt Bay on April 21, 1956 (Yocom, 1957).

Black brant have been reported to nest in the Humboldt Bay-Eel River area by Moffitt (1941) and California Fish and Game personnel (unpublished reports). The authors have not seen broods of brant.

We have summer records for several species of waterfowl which are not known to nest here; these species are: ruddy ducks (*Oxyura jamaicensis*), widgeons, green-winged teals (*Anas carolinensis*), scaup (*Aythya spp.*), white winged scoters (*Melanitta deglandi dixoni*), American scoters (*Oidemia nigra americana*), and surf scoters (*Melanitta perspicillata*).

BANDING STUDIES

Prior to 1953 an unknown number of birds were banded at Humboldt Bay under the direction of Fred Glover. In September 1953, 121 male pintails were banded at Humboldt Bay by personnel of the California Department of Fish and Game. There were no direct local recoveries of these pintails though birds from this banding were taken locally in subsequent years.

From 1953 to the present time, personnel of the Division of Natural Resources, Humboldt State College, Arcata, California, have banded 127 mallards, 156 pintails, 33 green-winged teal, 14 widgeons, 2 shovelers, 68 lesser scaup ducks (*Aythya affinis*), 3 redheads (*Aythya americana*), 1 bufflehead (*Bucephala albeola*), and 18 ruddy ducks.

Since 1948 California Fish and Game personnel have conducted extensive banding operations on both state and federal owned waterfowl areas within the state. Approximately one percent of all recoveries of ducks banded at Tule Lake, Honey Lake, Gray Lodge, Los Banos and Imperial Valley were made in Humboldt and Del Norte counties. The distance of these banding stations from the places of recovery precludes any bias from the birds failing to disperse.

Other federal and neighboring state agencies also banded birds which were recovered in northwestern California.

The information presented on Figures 2 to 5 was secured from several sources. Humboldt State College and California Department of Fish and Game records were compared for determination of points of recovery of birds banded by Humboldt State College. It was found that neither set of records was complete. Frank Kozlik, California Fish and Game Waterfowl Project Leader, provided summaries of returns on waterfowl banded in California and made available information on waterfowl banded in other states and Canada. Little information was available for birds taken after 1958 because of a fire in the Fish and Wildlife Service banding office. Some additional information was obtained from Hansen (1960).

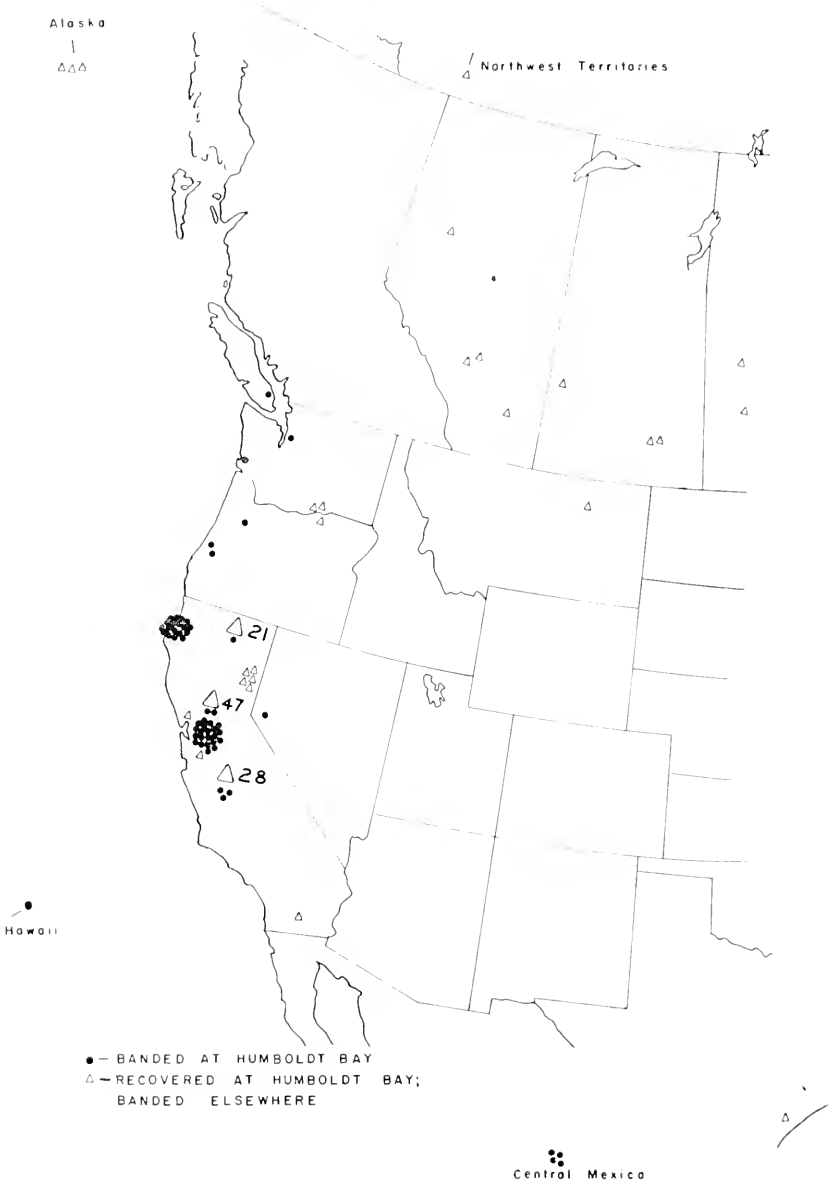


FIGURE 2. Recovery of pintails shot or banded at Humboldt Bay, California.

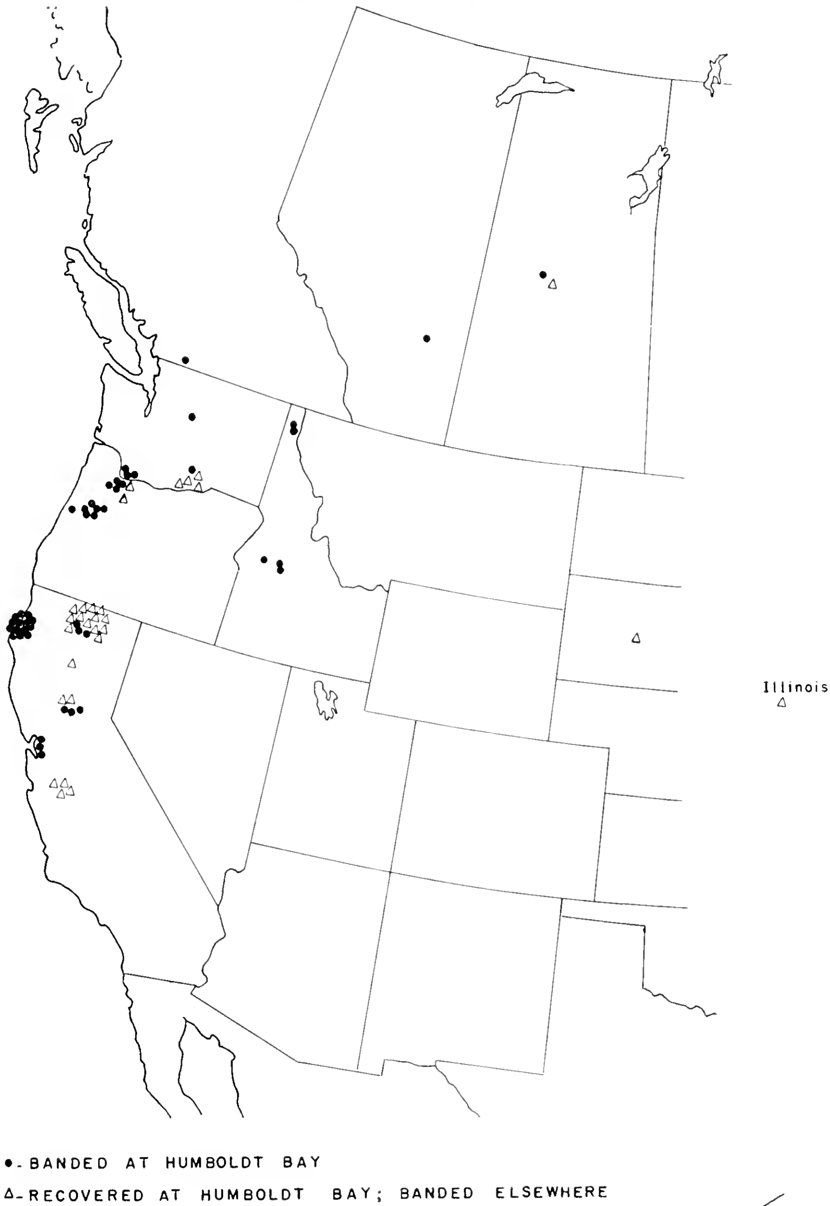


FIGURE 3. Recovery of widgeons shot or banded at Humboldt Bay, California.

RESULTS OF BANDING

Slightly less than one percent of all waterfowl banded and recovered in California are taken in Humboldt and Del Norte counties. The majority of these band recoveries on all species of waterfowl except gadwalls are reported from an area within twenty miles of Humboldt Bay. This is, at least in part, a reflection of the concentration of hunting in this area.

Nine gadwalls banded at Tule Lake, California, were taken at Lake Earl, Del Norte County. None were recovered at Humboldt Bay, although a few are taken there each year.

Few band returns on divers are available for northwestern California although they comprise an important proportion of the waterfowl wintering in this region (Table 1). Thirty three banded redheads were recovered on Humboldt Bay. Of these, thirty-two were banded at Tule Lake and one at Fallon, Nevada. Four banded canvasbacks (*Aythya valisineria*) were taken. Two were banded in British Columbia, one in Alaska and one at Hamer, Idaho. One lesser scaup banded in Alaska and one banded in British Columbia were reported from Humboldt Bay. A single bufflehead banded in British Columbia was taken on Humboldt Bay. Two ruddy ducks banded locally were recovered the following year in the area where they were banded.

The pattern of band returns within California (Figure 2) from pintails banded at Humboldt Bay indicates that there is considerable mixing of birds within the state. Birds banded at Humboldt Bay frequently were shot in the San Francisco Bay area, and birds banded at Tule Lake, Gray Lodge, and Los Banos waterfowl areas were killed on the northwest coast. The number of band recoveries of pintails (which exceeds that of other species) reflects greater success in banding these birds rather than their proportion in the wintering population (Table 1). According to a letter from W. C. Rienecker in 1961, 122 or 0.88 percent of 13,888 pintails banded within California were recovered in the northwest coastal area. Many of the pintails recovered at Humboldt Bay which were banded outside the state appear to come from the breeding grounds of the prairie provinces of Alberta, Saskatchewan and Manitoba. Field observations indicate that there is an early flight of pintails in August and September which passes by in the middle of October and a second flight in late November and December which remains in the Humboldt Bay area during the remainder of the winter. Band returns from Hawaii and Central Mexico and the recovery of an adult male pintail banded at Aransas, Texas, illustrate the wide movements of this species.

Figure 3 indicates that many of the widgeons which migrate through and winter in northwestern California come from the major breeding grounds in the prairies of Alberta and Saskatchewan, Canada, and apparently from the breeding areas in eastern Washington. The 46 locally banded widgeons shot on Humboldt Bay were primarily immature birds. They were banded during the interval between split seasons for the most part in late November 1951 and 1952 and killed in December the same years. This indicates that there is little movement of widgeons south from Humboldt Bay after the forepart of November. We feel that many birds arriving earlier are passing through to wintering areas further south.

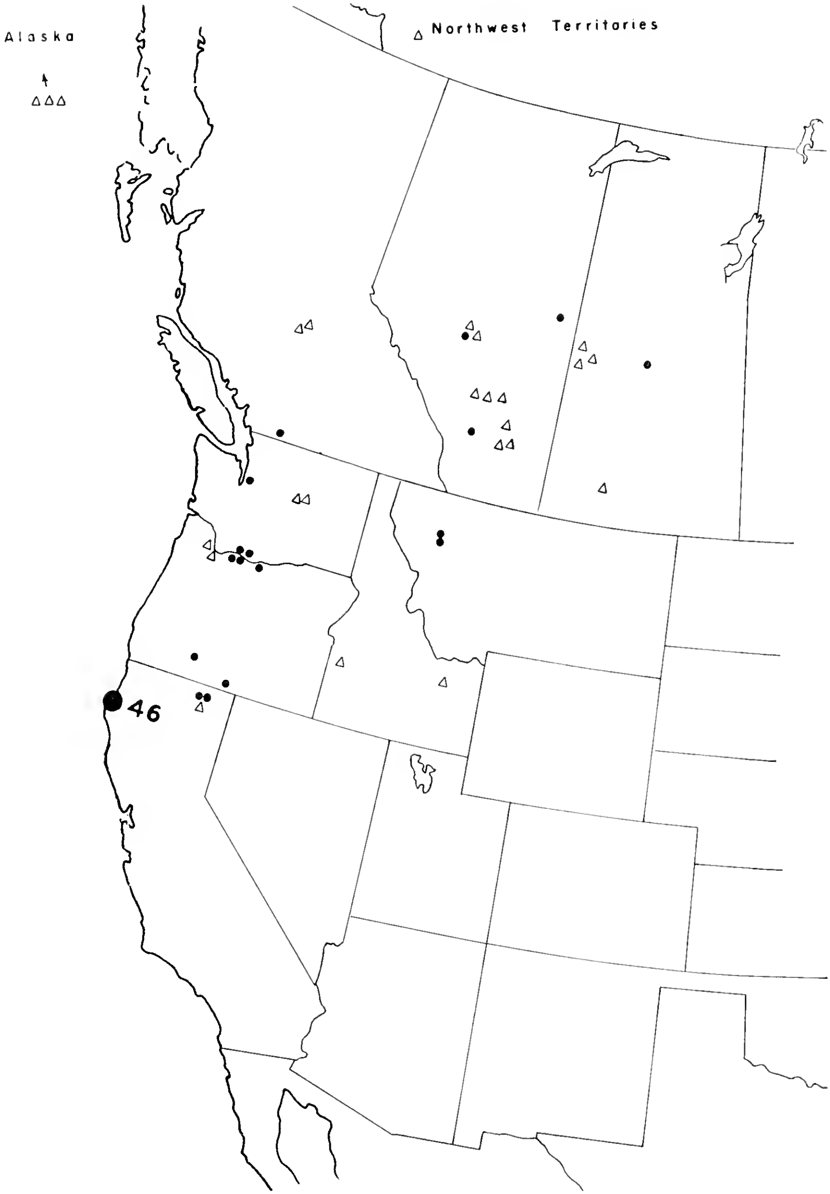
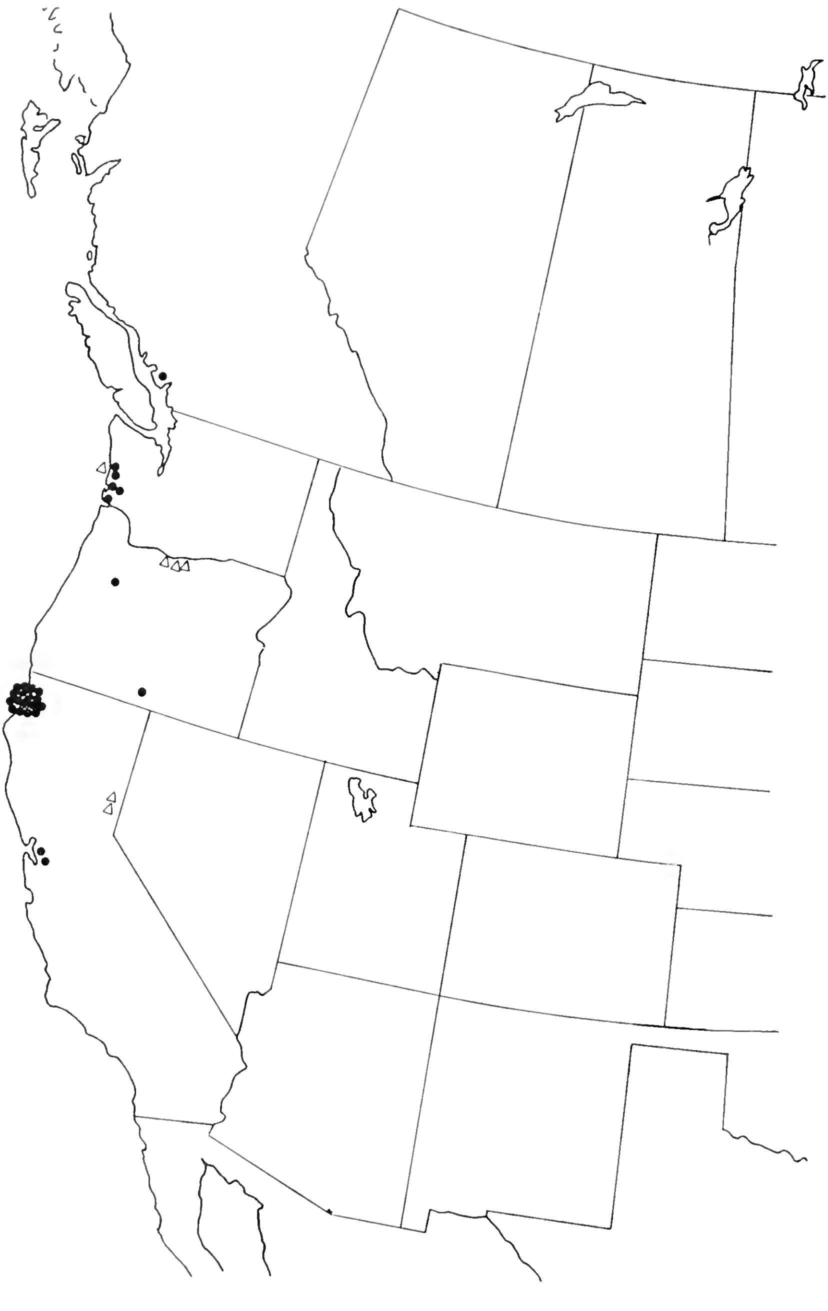


FIGURE 4. Recovery of mallards shot or banded at Humboldt Bay, California.



●– BANDED AT HUMBOLDT BAY
△– RECOVERED AT HUMBOLDT BAY; BANDED ELSEWHERE

FIGURE 5. Recovery of green-winged teal shot or banded at Humboldt Bay, California.

Mallards shot at Humboldt Bay include a large number of birds banded at Tule Lake, a few from the interior valleys of California and some from along the Columbia River between Washington and Oregon (Figure 4). Birds banded in Humboldt Bay and recovered later show a definite migrational pattern northeasterly through Oregon, Washington and Idaho to Alberta and Saskatchewan, Canada. The wintering population of mallards comprises a small proportion of the total wintering waterfowl and includes many local birds as well as migrants.

Our data is too meager to allow us to make any assumptions as to where the wintering green-winged teal breed (Figure 5). Birds banded at Humboldlt Bay have been recovered in the immediate coastal areas except for two shot in Oregon.

ACKNOWLEDGMENTS

The authors wish to thank Frank Kozlik and W. C. Rienecker, Game Management Branch, California Department of Fish and Game, for their cooperation in furnishing records of banded birds and for reading the manuscript. We also acknowledge the work Fred Glover and his students in Game Management at Humboldt State College carried on in banding waterfowl in the Humboldt Bay area prior to the fall of 1953. Many of their records are included in this paper. We also thank the many Humboldt State College Game Management students who have banded waterfowl in this area after the spring of 1953.

SUMMARY

The northwest coast of California is not an important breeding area for waterfowl because of limited suitable habitat. Ducks which commonly nest in this area are mallards, wood ducks, cinnamon teal and American mergansers. Other species known to have nested here are pintails, shovelers, and blue-winged teal.

Humboldt Bay, the lagoons and Lake Earl area are important wintering places for many ducks of which widgeons, pintails, and black brant are the most numerous. An important number of divers use Humboldt Bay as a wintering area.

Thousands of migrants pass through the northwest coastal region including black brant, lesser Canada geese, white-fronted geese, snow geese, cackling geese, widgeons, pintails, mallards, green-winged teal, cinnamon teal, shovelers, gadwall, blue-winged teal, redheads, canvasbacks, ruddy ducks, lesser and greater scaups (*Aythya marila*), scoters and mergansers.

Many of the pintails, widgeons and mallards apparently come from the prairie provinces of Canada passing through Idaho, Washington and Oregon on their migratory flights.

LITERATURE CITED

Anonymous
1955. Humboldt Bay California. A literature survey. University of Washington Department of Oceanography, 144 pp.

Bentley, W. W. and E. R. Christianson
1957. A continuous aerial inventory of waterfowl in the Humboldt Bay area. Unpublished report, Humboldt State College, Arcata, California.

Dollahite, Ned and M. P. Anderson, Jr.
1952. A new nesting record for the cinnamon teal in Humboldt County, California. Condor, vol. 54, no. 5, p. 320.

Gabrielson, Ira N. and Stanley G. Jewett
1940. Birds of Oregon. Oregon State College, Corvallis, Oregon, 650 pp.

Grinnell, Joseph and Alden H. Miller
1944. The distribution of the birds of California. Cooper Ornithological Club. Berkeley, California. Pacific Coast Avifauna no. 27, 608 pp.

Hansen, Henry A.
1960. Annual waterfowl report. Bureau of Sports Fisheries and Wildlife, Juneau, Alaska, pp. 1-28 (offset).

—— and Urban, C. Nelson
1957. Brant of the Bering Sea migration and mortality. Transactions of the twenty-second North American Wildlife Conference, Wildlife Management Institute, Washington, D.C., pp. 237-256.

Lauckhart, J. Burton
1956. Calculating mortality rates for waterfowl. The Murrelet, vol. 37, no. 3, pp. 31-34.

Lincoln, Frederick C.
1939. The migration of American birds. Doubleday, Doran and Company, Inc., New York, 189 pp.

Moffitt, James
1941. Eleventh annual black brant census in California. California Fish and Game, vol. 27, no. 4, pp. 216-233.

Munro, J. A.
1943. Studies of waterfowl in British Columbia: Mallard. Canadian Journal of Research, vol. 21, pp. 223-260.
1944. Studies of waterfowl in British Columbia: Pintail. Canadian Journal of Research, vol. 22, pp. 60-86.
1957. Observations of the winter waterfowl populations at Morro Bay, California. The Murrelet, vol. 38, no. 2, pp. 9-25.

Murrell, Stewart L.
1959. The eastern brant at Humboldt Bay, California. Condor, vol. 61, no. 5, p. 374.

Naylor, A. E.
1960. The wood duck in California with special reference to the use of nest boxes. California Fish and Game, vol. 46, no. 3, pp. 241-269.

Yocom, C. F.
1947. Observations on bird life in the Pacific Ocean off the North American Shores. Condor, vol. 49, no. 5, pp. 204-208.
1951. Waterfowl and their food plants in Washington. University of Washington Press, Seattle, Wash., 272 pp.
1957. Breeding record of pintail in Humboldt County, California. Condor, vol. 59, no. 5, pp. 340-341.
1961. Shovelers nesting in Humboldt County, California. California Fish and Game, vol. 47, no. 3, p. 301.

—— and Raymond Dasmann
1957. The Pacific Wildlife Region. Naturegraph Co., San Martin, Calif. 112 pp.

—— and Mathew Keller
1961. Correlation of food habits and abundance of waterfowl, Humboldt Bay, California. California Fish and Game, vol. 47, no. 1, pp. 41-53.

—— and W. A. Wooten
1956. Blue-winged teal in Del Norte County, California. California Fish and Game, vol. 42, no. 1, p. 81.

NOTES

WATER VELOCITIES TOLERATED BY SPAWNING KOKANEE SALMON

During a water projects investigation on November 4, 1960, an opportunity occurred to measure high ranges of water velocities tolerated by kokanee salmon (*Onchorhynchus nerka kennerlyii*) during their spawning activities. Such information is useful for establishing criteria to determine areas these fish might use for spawning.

The stream immediately below Bucks Lake Dam, Plumas County, was filled with a spawning run of kokanee and brown trout from Lower Bucks Lake. It was estimated that the kokanee spawners were 14 to 16 inches in length. Stream flow was approximately 100 cubic feet per second, and average stream width was about 25 feet.

A wide pool, just above a bridge crossing the stream, contained many spawning kokanee. From the bridge it could be seen that all the kokanee were crowded into the left half of the pool. No fish were in the right half, and a clear demarcation line existed between the used and unused areas. The line of separation was quite striking. A return trip three days later revealed that no change had occurred in the distribution of the fish, even with additional and fresher fish present in the stream. Close examination by wading, bottom disturbance, and measurement revealed that depths and gravel size were similar, if not identical, in both areas. The only obvious difference seemed to be the higher water velocities near the stream bottom in the unused area.

Depth and velocity measurements were made along the area being used, and the area not being used. Velocities were measured 0.20 feet from the stream bottom with a current meter to determine the velocities the fish were actually encountering during their redd digging. In some cases, the points of measurement on both sides of the demarcation line were within one foot of each other. The results of measuring water velocities and stream depths are presented in Table 1.

TABLE 1
Depth and Velocity of Water in Relation to Kokanee Spawning

Area with spawning		Area with no spawning	
Depth in feet	Velocity in feet per second	Depth in feet	Velocity in feet per second
1.6	1.50*	2.0	2.19
1.5	1.75	2.0	2.19
1.7	1.83	2.0	2.43
1.6	1.91	2.0	2.66
2.0	1.95		
1.8	2.15		

* Surface velocity over the spawning area margin was 2.67 Ft./Sec.

These data indicate: (1) the maximum velocity tolerated for spawning in this pool was approximately 2.15 feet per second, and (2) velocities of 2.19 ft. sec. and above were avoided. For practical purposes, it might be better to say that velocities of 2.20 ft. sec., or higher, were avoided by the kokanee spawners. Kokanee have been observed spawning in areas with no velocity, and these recent observations could help establish the water velocity range within which kokanee will spawn, *e.g.*, from 0.0 to 2.2 ft. sec. However, the optimum velocities for spawning and fry survival are yet to be determined.—*Glenn E. Delisle, Region 2, Water Projects, California Department of Fish and Game, June 1961.*

OBSERVATIONS ON THE FOOD HABITS OF JUVENILE WHITE STURGEON [1]

The stomachs and esophagi of 30 young-of-the-year white sturgeon (*Acipenser transmontanus*) were obtained at the United States Bureau of Reclamation's Tracy Fish Collecting Facility on Old River, eight miles northwest of Tracy, San Joaquin County, during August, September, and October of 1956 and 1958. All fish were preserved in 10 percent formalin. Their ages were determined by using cross sections of pectoral rays (Pycha, 1955).

The organisms in the stomach and esophagus of each sturgeon were identified and counted, and the volume of the contents was measured. The volume of each species of food material found in the stomach was determined by displacement in alcohol after the excess water had been removed with blotting paper.

All of the fish examined were in their first year of life (age 0), and their mean fork length was 8.0 inches.

Nine of the 30 stomachs examined were empty. The food in the remaining 21 stomachs is summarized in Table 1.

TABLE 1
Food Items Found in Juvenile Sturgeon

Food	Frequency of occurence (percent)	Stomach contents			
		Number			Volume
		Range	Mean	Total	Range
Corophium spinicorne	90	1–45	6	108	Trace—0.1 ml.
Neomysis mercedis	10	1	1	2	Trace
Tendipedidae					
Larvae	19	1–6	2	9	Trace—0.05 ml.
Adult	5	1	1	1	Trace

The stomachs contained only small amounts of food—the greatest volume in any one being 0.1 ml. This stomach contained 45 *Corophium spinicorne*, along with a trace amount of body and appendage parts. All others contained 14 organisms or less.

This sample is so small that no general conclusions may be made about the food habits of juvenile sturgeon. However, it would appear that their primary food in the southern portion of the Sacramento-San Joaquin Delta during the late summer and fall is the amphipod *Corophium spinicorne*. The shrimp *Neomysis mercedis*, and midge or

[1] This work was performed as part of Dingell-Johnson Project California F-9-R, "A Study of Sturgeon and Striped Bass," supported by Federal Aid to Fish Restoration funds.

tendipedid adults and larvae appear to be of lesser importance in the diet.

REFERENCES

Pycha, R. L.
1955. A quick method of preparing permanent fin-ray and spine sections. Prog. Fish Cult., vol. 17, no. 1, p. 192.

—Max R. Schreiber, Inland Fisheries Branch, California Department of Fish and Game, December 1960.

PURSE SEINING FOR PACIFIC ALBACORE

California's purse-seine fleet traditionaly has fished for yellowfin, skipjack and bluefin tuna, but shied away from the wary and elusive albacore. Occasionally, however, albacore (*Thunnus germo*) have been taken by purse seiners, either as pure schools or when mixed with bluefin tuna.

During the nine-year period 1951 through 1959, 19 seiners made incidental catches totaling 60 tons. The use of nylon webbing to make larger, lighter, and deeper nets; power blocks that permit fast and efficient retrieves (Figure 1); hydraulic and electrically controlled winches of improved design; plus other gear improvements have increased the desire among boat owners to seine tuna, and many high-seas tuna clippers have converted to purse-seine gear. The advent of these "clipper-seiners" among the purse-seine fleet brought about some interesting changes in catch statistics. In 1960, 16 seiners landed over 100 tons of albacore, nearly double the catch of the preceding nine years. One "clipper-seiner" actually sought albacore and accounted for slightly more than 30 percent of the total.

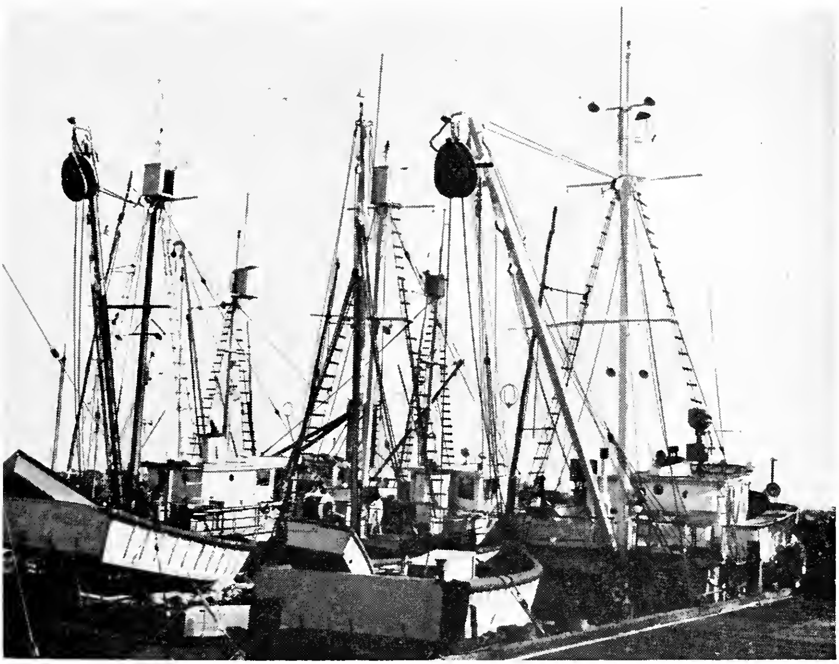


FIGURE 1. Purse seiners with and without power blocks. *(Photograph by Harold B. Clemens)*

In 1960, Canadian purse-seine fishermen expended a fair amount of effort attempting to capture the wily albacore. The seven Canadian vessels participating in this fishery originally had been designed for taking salmon and herring—not tuna; and the fisherman were not experienced with tuna behavior. Despite this, 70 tons of albacore were wrapped off the Columbia River in September, and a few weeks later approximately 80 tons were caught around the San Juan Seamount off southern California, making a total of 150 tons for this small northern fleet.

At the close of the season, American fisherman were still uncertain as to whether seining for albacore is either feasible or profitable. Canadian fishermen, however, feel that with better gear and refrigeration, there is a definite future to purse seining for albacore off Oregon and California.—*John A. Sharer, Marine Resources Operations, California Department of Fish and Game, August 1961.*

BOOK REVIEWS

Atlantic Ocean Fisheries

Edited by George Borgstrom and Arthur J Heighway, Fishing News (Books) Ltd., London, 1961; viii + 336 pp., illus. 3L 7s. 6d.

The first paragraph of the introduction states, in part, "This book has one vital purpose. It is to provide in one cover essential facts about the Atlantic Ocean (North and South) that are of value to practical fishermen, the executives of companies interested in the catching, processing, and marketing of fish, and the statesmen, scientists and administrators of the Fishery Departments of the various countries concerned with drawing food supplies for their populations from its waters." This is an ambitious undertaking and the editors appear to have accomplished their objective in the excellent job they did of compiling the one non-technical volume from the many chapters written by fishery administrators and experts from countries bordering the Atlantic Ocean.

The book is divided into four sections. Section 1 covers the Fundamental Factors concerning oceanography, biology, conservation, territorial limits, types of vessels and gear improvements. Section 2 is 22 individual chapters dealing with Industrial Development in countries bordering the Atlantic Ocean, Baltic Sea and Mediterranean Sea. Section 3 is on the giant effort Russia has mounted in the Atlantic and the development of some of their inland fisheries. Section 4 is a glossary of over 500 cross-indexed common and scientific names of fishes.

The typesetting and proofreading could be improved. For instance, the chapter on "The Fish Industry of Spain" has several text citations yet the bibliography contains only five references, all beginning with the letter A, leading one to believe the page containing the remainder of the references was not included.

This book should be on the required-reading list for everyone connected with fisheries. The information on the expansion of foreign fishing fleets, freezing trawlers, new areas of exploitation, and processing of fish for export to the United States certainly provides food for thought for our domestic fishing industry. A companion volume on Pacific Ocean Fisheries is in preparation—*E. A. Best, California Department of Fish and Game.*

Living Fishes of the World

By Earl S. Herald; Doubleday & Company, Inc., Garden City, New York, 1961; 304 pp.; 300 illustrations, 145 in color. $12.50.

Between the covers of this book appear some of the finest illustrations, nearly half in color, of living fishes ever published. These represent the best efforts of some sixty-odd photographers, many world-renowned.

Around these illustrations, the author, Dr. Earl Herald, has woven interesting and intriguing accounts that should pique every reader's interest. There is no complete life history information on any one fish; however, the generalized accounts are, for the most part, crammed with choice bits and gossipy items about the finny beasts inhabiting our oceans, lakes and streams.

Although most professional ichthyologists, and some amateurs, could point out a number of minor inconsistencies and places where the author has overlooked obvious, recent, pertinent works, it does not detract from its value to amateur and professional alike. Actually, the volume fulfills every requirement for which it was intended. In fact, Earl Herald has come up with a book which, with truths, glamorizes a field of science long overburdened by dry, stuffy volumes or semi-fictional tomes professing to be accurate accounts. He has done this by cook-booking just the right mixture of technical details, vital statistics, choice bits of wisdom and fish-lore into an extremely "edible" recipe.

No ichthyologist could fail to learn something "new" by a careful perusal of *Living Fishes of the World* and every person who is even remotely interested in fishes, or beautiful photographs, should own a copy.—*John E. Fitch, California Department of Fish and Game.*

The Great Barrier Reef and Adjacent Isles

By Keith Gillett and Frank McNeill; Coral Press Pty. Ltd., Paddington, Sydney, Australia, 1959; 194 pp., illus., $10. (U.S.A.)

In the words of the authors, this book represents "a comprehensive survey for the visitor, naturalist and photographer" to the area of the Great Barrier Reef off the east coast of Australia. These few modest words do not do justice to this fine piece of workmanship, although a briefer, more fitting summary could not be written. Mr. I. M. Mackerras (Director of the Queensland Institute of Medical Research), who penned the introduction, accords it the honor of being the third great classic dealing with ecology of the Reef. The first two were the works of Saville Kent (1893) and C. M. Yonge (1930).

A near perfect wedding of verbal and pictorial presentation resulted when a qualified Australian naturalist photographer, Mr. Gillett, and an equally well-qualified zoologist, Mr. McNeill, combined their talents to produce this volume. The text provides a most interesting discussion of the Reef from the theories of its formation to the composition of its fauna. A similar treatment of the flora, fauna and facilities of the associated islands is interspersed throughout. Pictorially, the text is supplemented by exceptional plates; 27 in full color and 133 in black and white. The plates are so well captioned each is an interesting story by itself. One text chapter is devoted entirely to the surface and submarine photographic techniques developed by the senior author during his years of accumulating material for the book. Two short appendices guide visitors to the legal restrictions on collecting and safety hints for the unwary. All of the scientific names in the text are included in a cross-indexed glossary and the whole book is thoroughly indexed.

Although it is written primarily as a guide for the fortunate visitor to the Great Barrier Reef, the book is well-worth owning for its pleasing literary style and fine collection of excellent photographs describing the ecology of one of nature's more fascinating phenomena.—*William L. Craig, California Department of Fish and Game.*

Things to Do in Science and Conservation

By Byron Ashbaugh and Muriel Beuschlein; The Interstate Printers and Publishers Inc.; Danville, Illinois, 1960; 163 pp., $2.50.

This book is written to be an aid to instructors in the teaching of Conservation. Its emphasis is upon methods and demonstration techniques. Inclusion of an integrated study of resources is encouraged at all educational levels.

Each chapter is devoted to a separate resource such as plants, minerals, soil, etc., which emphasizes: (1) the concept, (2) methods of demonstration and (3) group or individual projects.

Although trained fish and game workers will class this book as too elementary, it should prove a definite aid to teachers in both primary and secondary schools.—*Willis A. Evans, California Department of Fish and Game.*

Man and Dolphin

By John C. Lilly, M.D., Doubleday and Company, Inc., Garden City, N.Y., 1961; 312 pp., illus. black and white photographs, $4.95.

This is an unusal book by an imaginative scientist. His main thesis is that man will shortly speak with another kind of animal. The initial discussion of this thought early in the book seemed naïve. However, as Dr. Lilly's story of his work and experiences with dolphins unfolded, this impression faded.

The dolphin's brain is comparable with the human brain in complexity and proportionate size. This and other characteristics led Dr. Lilly to conclude "It is probable that their intelligence is comparable to ours though in a very strange fashion." and again, "We do not know to what degree these animals communicate with one another, though it looks as if they do so at a very complex descriptive level."

The book tells of interesting experiences with a succession of individual dolphins. Apparently people working with these animals quickly develop a feeling for them different than that experienced with other animals because of the dolphin's intelligence, individuality, and charm.

Other chapters describe the anatomy and physiology of dolphins, their voices, their brains, and studies of reactions resulting from stimulating various parts of their brains electrically.

The trials involved in setting up a substantial marine laboratory in the Virgin Islands, suitable for work with live dolphins, illustrate very well the difficulties encountered in financing scientific work which is out of the ordinary.

This is an intriguing book well worth reading.—*Alex Calhoun, California Department of Fish and Game.*

Animal Sounds and Communications

Edited by W. E. Lanyon and W. N. Tavolga; American Institute of Biological Sciences, Washington, D.C., 1961; 443 pp., one 12-inch L.P. record, $9.50.

This volume presents the proceedings of a symposium held at the AIBS meetings at Bloomington, Indiana, in September 1958. A standard 12-inch L.P. record prepared from the tape recordings accompanying the papers presented at the meetings is included.

A paper by Peter Paul Kellogg reviews techniques used in bio-acoustic studies. The author is professor of ornithology and biological acoustics at Cornell University, so is in a good position to give reliable advice on the subject. He discusses equipment and material requirements, field techniques, tape editing, cataloging, storage of tape and equipment maintenance.

Donald J. Borror discusses analysis of animal sounds and, to this reviewer, his demonstration recordings were the best on the accompanying record.

Richard D. Alexander presents a paper on sound communication on Orthoptera and Cicadidae. Charles M. Bogert discusses the influence of sound on the behavior of amphibians and reptiles. This is the longest contribution in the symposium and appears to be a definitive work on the subject. He adds in a very clear way the spectrographic analysis of mating calls to the tools of the taxonomist. The existence of species can be determined by this method that would be overlooked by systematists using better known methods of call description or morphological criteria. The recordings accompanying this paper are also good.

Avian vocalizations are described in papers by Wesley E. Lanyon and Peter Marler. The recordings accompanying Lanyon's paper, at least in my record, had more background noise than usual.

Nicholas E. Collins illustrates his paper on the classification of animal sounds with a series of chicken recordings. These were good and those readers who were raised on a farm will recognize and agree with the assigned purpose of the various calls. I get the impression he was trying to "bridge the gap" between the more common call description method of studying animal and bird sounds and the newer spectrographic analysis technique. This, however, may be an artifact introduced by the reviewer.

This collection of papers is closed by an article on the study of animal communication by Charles F. Hockett.

I was attracted to this volume because of an interest in fish sounds. William N. Tavogla presents a paper on sound production and underwater communication in fishes. In addition to a discussion of examples of sound mechanisms and attendant behavior, he includes a brief section on equipment that is useful and complements Kellogg's more extensive treatment of the subject. It also explains the irritating background noise found in recordings of fish sounds. The demonstration record has the typical background burbles of underwater recordings. In his description of various sounds produced by the various fishes he has studied there is quite a lot of good technique information.

This book is of primary interest to a relatively small audience. It is well made and the demonstration record is of good quality. It would serve as a good introduction to the field of animal sounds and communication.—*J. B. Kimsey, California Department of Fish and Game.*

New Mexico Birds

By J. Stokley Ligon; The University of New Mexico Press, Albuquerque, 1961, XXI + 360 pp., illus. with 86 photos, maps and drawings and 34 color plates, $8.50.

The author has fashioned an attractive volume, a worthy addition to the ornithological literature of the Southwest.

The *Introduction* describes the topography and climate of the state, the life zones, and gives an account of the early history of ornithology of the region. General notes on birds are included.

The section, *Descriptions*, takes up each species and gives means of identification, general notes, distribution and nesting data.

Appendixes include a list of rare and stray birds, flyway records, and a section on bird watching. Under *Bird Watching*, the state is divided into regions which are described and a listing of birds to be found in each region is given.

The author has drawn on a number of individuals for illustrations and the quality varies from fair to excellent.

Thirty-two of the 34 color plates are grouped in the back of the book. This reviewer would have preferred that they be placed throughout, near the appropriate narrative material. *C. M. Ferrel, California Department of Fish and Game*.

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