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"CONSERVATION OF WILDLIFE THROUGH EDUCATION"

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CONTENTS

Notes

IN MEMORIAM

John E. Skinner

We have lost a close friend and a dedicated, innovative fishery biologist. John E. Skinner, 52, died in a tragic home fire in the early morning hours of December 19, 1978. His home was in Rancho Cordova, near Sacramento, where he lived with his wife Marjory and four of their six children. Although hurt, the remainder of the family survived.

John was employed by the California Department of Fish and Game for nearly 25 years. He was Coordinator of the State Water Use Planning Project since March 1976, working closely with the California Water Commission and the Department of Water Resources.

A native of Detroit, Michigan, he was a graduate of Michigan State University with a degree in fisheries and wildlife. He served as a machinist's mate in the U.S. Navy at the close of World War II and worked as a journeyman carpenter and in aircraft fabrication and metallurgy.

John joined the California Department of Fish and Game early in 1954 as a Junior Aquatic Biologist assigned to the Inland Fisheries Branch. His assignments over the years included 3 years as a researcher on statewide angling statistics and on the fisheries of the Sacramento-San Joaquin Delta, more than 9 years as Water Projects Supervisor, and 8 years as Research Supervisor on the Bay-Delta Study. Among John's technical publications is the classic 225 page document, "An Historical Review of the Fish and Wildlife Resources of the San Francisco Bay Area".

He was the current president of the Western Division of the American Fisheries Society and was a former president, vice-president, and secretary-treasurer of the California-Nevada Chapter. He was also affiliated with the Pacific Fishery Biologists and the Western Section of the Wildlife Society, of which he was a one-time member of the Executive Board. The various professional committees he worked on are too numerous to mention.

John was also very active in civic, school, and church affairs. He was a member of the California Commonwealth Club and the philosophy and goals committee of Folsom-Cordova Unified School District. He served as president of the St. John Vianney parochial school board and was past president of the school's Parents Club.

The foregoing summarizes his impressive accomplishments and contributions, yet does not describe John as a person. What set John apart from others was the monumental enthusiasm and dedication with which he met any challenge, whether it was cooking a cioppino dinner for 400 people at the Western Division meeting or solving some major resource protection problem. Because of his strong faith in people, he often kindled in them these same attributes.—*Almo Cordone*

Calif. Fish and Game 65(3): 141–150. 1979.

EFFECTS OF A 305-MM (12.0-INCH) MINIMUM SIZE LIMIT ON LARGEMOUTH BASS, *MICROPTERUS SALMOIDES,* AT MERLE COLLINS RESERVOIR [1]

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A 305-mm minimum size limit on largemouth bass, *Micropterus salmoides,* imposed in 1972 at Merle Collins Reservoir, Yuba County, was evaluated by an extensive creel census. Angler harvest of largemouth bass was reduced over 50%, with good public acceptance and without reductions in game fish yields. Combined annual weights of largemouth and smallmouth bass, *M. dolomieui,* decreased only about 3%. The size limit apparently also protected smallmouth and spotted bass, *M. punctulatus,* less than 305 mm total length.

INTRODUCTION

Size limits have been used by other states to control overharvest of largemouth bass and to attain desirable predator-prey structure by protecting bass large enough to prey on slow-growing panfish and other fishes which compete with smaller bass (Funk 1974). Estimated annual exploitation rates as high as 0.65 at Merle Collins Reservoir (Rawstron and Hashagen 1972) prompted the Fish and Game Commission, at the request of the Department, to impose an experimental 305-mm size limit on largemouth bass in March 1972.

A continuing creel census begun in 1965 provided a means to follow the effects of the size limit on the fishery and to assess its value as a management tool. Hashagen (1973) provides detailed information on the census through 1972 and a description of Merle Collins Reservoir and its fishery.

METHODS AND MATERIALS

A creel census, modified from Best and Boles (1956), was the principal method used to evaluate the size limit. From June 1965 through June 1977, departing anglers were censused at the only point of exit from the reservoir on two rotating weekdays per week, on all weekend days, and on all national holidays. All anglers were interviewed each census day from 9:00 a.m. to dusk and a substantial proportion of all fish were weighed and measured.

During the spring, summer, and fall of 1973 and 1974, a complete census was conducted for seven continuous days and nights to determine how many anglers were missed by the 9:00 a.m. to dusk census. The complete census showed that about 30% of the anglers were not censused on regular census days. Missed anglers included those who stayed in the campground for two or more days before passing the census station, and anglers who fished only during the early morning hours or at night.

Creel census data were expanded to give estimates of total catch by mutiply-

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[1] This work was performed as part of Dingell-Johnson Project F-18-R, "Coldwater Reservoir and Special Experimental Reservoir Management Program", supported by Federal Aid to Fish Restoration funds. Accepted for publication January 1979.

ing the observed monthly weekday catch of each species by the ratio of the total number of weekdays in a month to the total weekdays censused and adding the observed catches for weekends and holidays. Monthly estimates were then summed to obtain annual estimates. These were further expanded in all years by 30% (as determined by complete creel checks) to account for anglers not censused. Estimated total pounds of fish caught annually were calculated by multiplying the estimated total monthly catch of a species by the average monthly weight for that species and summing monthly estimates. Total annual poundages were included in the tables in addition to yield values since mean annual surface acreage, which typically fluctuates, was used to calculate yield.

An interview was included as part of the census in May 1973 to gain information on the number of bass caught and released. Anglers were questioned regarding fish preference, whether they were fishing for bass, whether they released any bass, and sizes of released bass.

Data from 1968 through 1971 and 1973 through 1976 were chosen to evaluate the size limit since they appeared most representative. Annual weights for largemouth bass for 1968 through 1970 were nearly identical (Hashagen 1973), indicating a stabilization of the fishery. Data for years 1965 through 1967 were excluded because the bass fishery was dominated by an extremely large 1964 year class which grew slowly and suppressed bass recruitment. Data for 1977 were not included because drought conditions severely reduced angler effort. Data for 1965 through 1967 are included for reference only.

Catch and effort values typically fluctuate from year to year. For this reason, pre- and post-size limit data were compared by averaging values for the two 4-year periods.

RESULTS

General

Angler use pre- and post-imposition of the size limit was comparable. Over the period 1968 through 1971, the number of anglers annually using the reservoir averaged 17,316 and the number of hours they expended averaged 76,242. Respective values for the period 1973 through 1976 were 19,256 and 82,482 (Table 1). The average number of hours annually expended by "bass anglers", defined by Hashagen (1973) as boat anglers fishing during March, April, May, and June using lures, minnows, or a combination of these methods, increased from 9,571 before 1972 to 14,769 after 1972 (Table 2).

Annual weight landed and yield values for all game fishes combined and for all centrarchids combined before and after the size limit were comparable. Pre-size limit annual weight for all game fishes averaged 4,823 kg with a corresponding yield value of 13.5 kg/ha. Respective post-size limit values were 4,664 kg and 13.6 kg/ha (Table 1). Pre-size limit annual weight for all centrarchids combined averaged 2,453 kg with a yield value of 6.8 kg/ha. Post-size limit values were 2,500 kg and 7.4 kg/ha. Combined annual weights of largemouth and smallmouth bass decreased only about 3%, from a pre-size limit yearly average of 1,786 kg to a post-size limit average of 1,731 kg (Tables 2 and 3).

Largemouth Bass

Pre- and post-size limit data show that after 1972 anglers caught nearly as many largemouth bass as before but retained about 52% fewer. From 1968

TABLE 1. Creel Census Data for Merle Collins Reservoir, Showing Estimated Total Anglers and Hours, Estimated Total Weight and Yield for All Fish and for All Centrarchids, and Mean Annual Surface Acreages Used for Calculating Yield Values

	YEAR											
	1965	*1966*	*1967*	*1968*	*1969*	*1970*	*1971*	*1972*	*1973*	*1974*	*1975*	*1976*
Total anglers	4,876	7,319	11,717	14,469	16,811	15,973	22,012	17,852	21,097	20,907	18,856	16,166
Total hours for all anglers	18,600	24,846	39,756	51,380	68,958	75,590	109,039	92,187	92,906	84,118	73,403	79,501
Estimated total weight for all fish (kg)	1,006	1,492	3,651	2,815	5,176	4,330	6,970	4,974	5,014	5,374	4,161	4,107
Estimated total weight for all centrarchids (kg)	985	1,293	2,344	1,583	2,311	2,381	3,537	2,059	2,463	2,774	2,323	2,440
Yield for all fish (kg/ha)	2.9	4.9	10.1	8.1	14.9	12.1	18.9	14.8	13.4	14.8	11.4	15.0
Yield for all centrarchids (kg/ha)	2.8	4.2	6.5	4.6	6.6	6.6	9.6	6.1	6.6	7.6	6.4	8.9
Mean annual surface acreage	855	755	890	855	860	885	910	830	922	900	901	675

TABLE 2. Largemouth Bass Catch Statistics

	YEAR											
	1965	*1966*	*1967*	*1968*	*1969*	*1970*	*1971*	*1972*	*1973*	*1974*	*1975*	*1976*
Estimated annual catch for all anglers	6,275	10,099	10,985	5,122	2,771	2,770	3,986	1,720	1,936	1,548	1,623	1,850
Estimated annual weight (kg)	783	909	1,901	1,253	1,257	1,271	2,035	1,095	1,290	1,023	1,040	1,082
Mean total length (mm)	199	188	233	277	296	304	324	348	380	367	358	335
Mean weight (g)	122.5	90.7	172.4	244.9	381.0	458.1	512.6	635.0	707.6	653.6	648.6	612.4
Yield value (kg/ha)[a]	2.3	3.0	5.3	3.6	3.6	3.5	5.5	3.2	3.4	2.8	2.8	4.0
No. < 305 mm released by all anglers	–	–	–		–	–		–	1,673[e]	4,264	2,237	2,036
No. < 305 mm retained (sublegal) by all anglers	–							–	103[e]	170	64	94
No. ≥ 305 mm released by all anglers								–	254[e]	200	433	1,066
Total hours for "bass anglers"	1,031	2,856	6,579	6,708	11,191	8,533	11,852	9,364	17,814	12,954	11,886	16,422
Catch/hour for "bass anglers"	0.24	0.27	0.36	0.33	0.14	0.13	0.20	0.10	0.20[b,d] 0.09[c]	0.26[b] 0.06[c]	0.24[b] 0.09[c]	0.19[b] 0.07[c]

[a] Yield values determined using mean annual surface acreage
[b] Includes all fish (legal, released, and sublegal)
[c] Legal fish only.
[d] May and June only.
[e] May through December only

TABLE 3. Smallmouth Bass Catch Statistics

	YEAR											
	1965	*1966*	*1967*	*1968*	*1969*	*1970*	*1971*	*1972*	*1973*	*1974*	*1975*	*1976*
Estimated annual catch for all anglers	355	1,310	719	442	834	938	1,500	830	1,006	1,540	1,302	1,562
Estimated annual weight (kg)	41	188	170	136	378	401	413	364	424	699	641	726
Mean fork length (mm)	186	217	258	266	261	301	271	305	305	303	317	308
Mean weight (g)	117.9	145.1	235.9	313.0	272.1	426.4	276.7	440.0	444.5	489.9	503.5	499.0
Yield value (kg/ha)	0.12	0.62	0.47	0.39	1.09	1.12	1.12	1.08	1.14	1.92	1.76	2.66
No. < 203 mm released by all anglers	–	–	–	–	–	–	–		222[d]	406	315	633
No. ≥ 203 mm released by all anglers	–	–	–	–	–	–	–		124[d]	395	546	653
Catch/hour for "bass anglers"	0.01	0.04	0.03	0.01	0.03	0.02	0.05	0.03	0.02[a c]	0.08[a]	0.07[a]	0.08[a]
									0.01[b]	0.05[b]	0.04[b]	0.04[b]

[a] Includes retained fish and released fish >203 mm

[b] Retained fish only

[c] May and June only

[d] May through December only

through 1971, anglers kept a total of 14,649 fish compared to 6,957 retained from 1973 through 1976 (Table 2). The mean total weight of largemouth bass caught and retained annually declined from 1,454 kg for pre-size limit years to 1,109 kg for post-size limit years, about a 24% decrease. There was a corresponding 22% decline in mean yield of from 4.1 kg/ha to 3.2 kg/ha. As could be expected, the mean length and mean weight of creeled fish increased.

There apparently was no reduction in the catch per hour (bass kept and bass released in combination) for "bass anglers". The catch per hour for largemouth bass retained by this group decreased over 60%, however (Table 2).

The size limit was favorably accepted by the majority of anglers. Only 431 sublegal largemouth bass were observed by the census clerks from 1973 through 1976. During this period, anglers creeled an estimated 6,957 legal fish and reported releasing 10,210 sublegal and 1,953 legal fish (Table 2). It is not known how many of the released fish were caught more than once. Also, it is not known how many of the released largemouth were actually smallmouth bass reported by anglers who could not differentiate between the two species.

Smallmouth and Spotted Bass

Anglers caught considerably more smallmouth bass after imposition of the size limit. The mean annual catch from 1968 through 1971 was 928 compared to 1,352 for the 4 years after 1972, an increase of about 46% (Table 3). This does not reflect the 3,294 smallmouth bass that anglers reported releasing from 1973 through 1976. The mean annual weight of smallmouth retained increased about 88% and yield values doubled after 1972. Mean length and mean weight increased substantially, the latter by 50%. Spotted bass, introduced in 1970, were not observed in the catch until 1973. Mean total length was greater than 305 mm in most post-size limit years (Table 4).

TABLE 4. Spotted Bass Catch Statistics

	YEAR						
	1970	*1971*	*1972*	*1973*	*1974*	*1975*	*1976*
Estimated annual catch for all anglers	–	–	–	22	13	32	28
Estimated annual weight (kg)	–	–	–	1	2	7	5
Mean fork length (mm)	–	–	–	270.4	343.8	336.5	320.2
Mean weight (g)	–	–	–	244.9	635.0	621.4	412.8
Yield value (kg/ha)	–	–	–	0.00	0.01	0.02	0.02

Other Centrarchids

The annual catch of redear sunfish *Lepomis microlophus*, more than doubled after 1972 (Table 5). Following the size limit, the annual weight increased by nearly 98%, while yield values doubled. There was, however, little change in the mean length or mean weight of fish observed in the census. Yield, annual catch, and annual weight landed for bluegill, *L. macrochirus*, declined by about 20% following 1972 (Table 6). Mean weight increased by about 53%, while mean length increased slightly. Annual catch, annual weight, and yield values for black crappie, *Pomoxis nigromaculatus*, decreased following 1972 (Table 7). Mean length and mean weight increased, however, the latter by about 69%. Mean length and mean weight of green sunfish, *L. cyanellus*, increased after 1972 (Table 8). Declines occurred, however, in all other catch figures.

TABLE 5. Redear Sunfish Catch Statistics

	YEAR											
	1965	*1966*	*1967*	*1968*	*1969*	*1970*	*1971*	*1972*	*1973*	*1974*	*1975*	*1976*
Estimated annual catch for all anglers	0	10	31	263	1,624	1,512	1,863	2,680	2,824	4,019	2,316	2,338
Estimated annual weight (kg)	0	2	8	48	240	244	247	302	320	499	288	434
Mean fork length (mm)	0	191	236	282	183	193	191	186	185	187	227	217
Mean weight (g)	0.0	213.2	249.5	181.4	149.7	163.3	131.5	113.4	120.2	131.5	158.8	226.8
Yield value (kg/ha)	0.00	0.01	0.02	0.14	0.69	0.68	0.67	0.90	0.86	1.37	0.79	1.59
Catch/hour[a]	0.00	0.00	0.00	0.04	—	0.05	0.09	0.14	0.18	0.15	0.11	0.09

[a] Anglers fishing from either a boat or from shore from June through October and using worms for bait

TABLE 6. Bluegill Catch Statistics

	YEAR											
	1965	*1966*	*1967*	*1968*	*1969*	*1970*	*1971*	*1972*	*1973*	*1974*	*1975*	*1976*
Estimated annual catch for all anglers	46	518	724	1,078	4,786	3,881	3,236	1,267	2,947	3,102	2,813	1,600
Estimated annual weight (kg)	3	51	87	108	387	314	234	103	245	231	210	119
Mean fork length (mm)	173	155	168	167	146	153	152	162	164	156	180	173
Mean weight (g)	68.0	99.8	117.9	99.8	81.6	81.6	72.6	81.6	90.7	108.9	158.8	154.2
Yield value (kg/ha)	0.01	0.17	0.24	0.31	1.11	0.88	0.64	0.31	0.66	0.63	0.58	0.44
Catch/hour[a]	0.00	0.04	0.04	0.18	—	0.21	0.40	0.05	0.15	0.16	0.20	0.07

[a] Anglers fishing from either a boat or from shore from June through October and using worms for bait

TABLE 7. Black Crappie Catch Statistics

	YEAR											
	1965	*1966*	*1967*	*1968*	*1969*	*1970*	*1971*	*1972*	*1973*	*1974*	*1975*	*1976*
Estimated annual catch for all anglers	6	12	22	24	57	597	3,284	569	631	1,269	337	180
Estimated annual weight (kg)	0	1	8	5	15	128	596	172	161	306	121	64
Mean fork length (mm)	–	241	299	233	252	227	218	263	255	248	281	285
Mean weight (g)	–	99.8	340.2	213.2	263.1	213.2	181.4	303.9	317.5	281.2	417.3	453.6
Yield value (kg/ha)	–	0.00	0.02	0.01	0.04	0.36	1.62	0.51	0.43	0.84	0.33	0.23
Catch/hour [a]	0.00	0.00	0.00	0.00	–	0.07	0.43	0.08	0.11	0.18	0.04	0.01

[a] Anglers fishing either from a boat or from shore during April, May, or June and using minnows as bait

TABLE 8. Green Sunfish Catch Statistics

	YEAR											
	1965	*1966*	*1967*	*1968*	*1969*	*1970*	*1971*	*1972*	*1973*	*1974*	*1975*	*1976*
Estimated annual catch for all anglers	1,507	1,938	2,293	600	543	328	199	286	326	360	403	267
Estimated annual weight (kg)	158	142	170	33	34	23	12	23	22	14	16	10
Mean fork length (mm)	165	151	146	144	138	152	146	161	156	165	211	178
Mean weight (g)	104.3	72.6	72.6	54.4	63.5	68.0	59.0	81.6	81.6	113.4	40.8	68.0
Yield value (kg/ha)	0.46	0.46	0.47	0.10	0.10	0.06	0.03	0.07	0.06	0.04	0.04	0.04
Catch/hour [a]	0.08	0.15	0.12	0.09	—	0.02	0.02	0.02	0.01	0.02	0.02	0.01

[a] Anglers fishing from either a boat or from shore from June through October and using worms for bait

DISCUSSION

Imposition of a size limit on largemouth bass carries with it the potential for certain negative impacts:

(1) A decline in the growth rate of largemouth bass resulting in the stockpiling of fish at lengths below the size limit.
(2) Overpredation on species which provide angling opportunity as well as forage.
(3) High mortality of angler caught undersized bass which are released.
(4) Low angler acceptance with a subsequent decline in fishing effort.

Creel census data and observations made during electrofishing operations provided no evidence that any of these occurred following establishment of the size limit at Merle Collins Reservoir.

Following reductions in the take of largemouth bass, other states have reported the stockpiling of bass at lengths just under a size limit (Funk 1974). Apparently this did not occur. Electrofishing operations conducted from 1973 through 1977, years of average to below average reproduction (R. Rawstron, Assoc. Fish Biol., Dept. Fish and Game, pers. commun.) did not show unusually large numbers of bass from 203 mm (the size most bass entered the catch in the absence of a size limit) to 304 mm total length (TL). It is reasonable to assume that in 1972, the year the size limit was instituted, a group of fish in this range was largely protected from angling mortality. Most of these fish, however, likely entered the catch during the following year and were replaced in the protected group by fish produced in 1971. This probably occurred each year. Stockpiling of bass just under the size limit would likely occur when growth rates are seriously retarded (Funk 1974). Preliminary analysis of age and growth data based on scale measurements indicates that a decline in the growth rate of largemouth bass at Merle Collins Reservoir did not occur during the period of this study.

Results of this study do not indicate that protected largemouth bass effected a substantial reduction in the panfish forage base. Considerable numbers of panfish less than 102 mm TL, particularly bluegill, were observed during electrofishing work in years following 1972.

Because hooking mortality will diminish the effectiveness of size restrictions, it was essential that the magnitude of immediate and delayed mortality of sublegal fish be determined. Therefore, a companion study was conducted from January through March 1976 at the Department's Field Station in Sacramento to assess hooking mortality of sublegal largemouth bass. Results of this study suggest that direct mortality due to hooking is not a factor which materially reduces the value of size limit regulations (Pelzman 1978).

Angler acceptance of the size limit was good. Most anglers interviewed expressed satisfaction with the regulation and some traveled considerable distances to fish at the reservoir because of the size limit. Anglers organized into clubs were especially supportive.

Tagging studies of largemouth bass conducted before and after the size limit provided comparable estimates of annual exploitation and survival rates. Rawstron and Hashagen (1972) reported an exploitation rate of 0.65 and survival rates of 0.24 and 0.19 in 1968 and 1969, respectively, for fish >203 mm (8.0 inches) fork length (FL). Exploitation and survival rates of 0.60 and 0.21, respectively, for fish ≥305 mm TL were recorded in 1973 (Rawstron and Pelzman 1978).

Substantial increases in the annual catch of smallmouth bass were recorded following establishment of the size limit. While the size limit may have contributed to increases in the smallmouth take, the increasing smallmouth population played a substantial role. The estimated annual take of smallmouth steadily increased to a high of 1,500 fish in 1971, the year before the size limit was imposed. During the 4 years following 1972, the annual catch averaged 1,352 fish, compared to 928 for the 4 years prior. A tagging study of smallmouth bass ≥203 mm FL, initiated in 1976, provided a weighted estimate of mean annual exploitation rate of 0.66 and an estimated survival rate of 0.16 (Pelzman, Rapp, and Rawstron, in prep.). These values are comparable to those for largemouth bass at Merle Collins Reservoir (Rawstron and Hashagen 1972; Rawstron and Pelzman 1978).

The size limit apparently protected smallmouth bass less than 305 mm TL in that they were released by anglers unable to distinguish them from largemouth. Angler interviews revealed that species identification was a common problem among anglers. An increase of over 25.4 mm in the mean length of smallmouth in the catch following imposition of the size limit suggests that anglers selected for fish that met the largemouth size requirement. In no year after the size limit was in effect was the mean total length for smallmouth bass less than 305 mm (Table 3).

Spotted bass constituted only a minor portion of the Merle Collins Reservoir fishery. It is probable, however, that the size limit served to protect spotted bass since very few anglers could differentiate them from largemouth bass. Twenty-three of the 38 spotted bass measured in the census from 1973 through 1976 were 305 mm or greater TL. Considerable increases in the spotted bass population were noted during electrofishing operations in 1975, 1976, and 1977. Most fish observed were less than 305 mm in length.

The annual catch of redear sunfish more than doubled (118%) after 1972, while bluegill catches decreased by about 20%. These changes are more likely related to population shifts that began before 1972 than to an influence of the size limit. Pre-size limit census data showed that redear were steadily increasing in the catch. Observations made during electrofishing operations conducted prior to 1972 suggested that redear were replacing bluegill as the dominant panfish. Large numbers of bluegill less than 102 mm TL, however, were observed during electrofishing work in 1976 and 1977. It is not known if changes in catch data for black crappie or green sunfish were related to the size limit.

Several events occurred at Merle Collins Reservoir following 1972 which altered the fishery and may have affected the impact of the size limit:

(1) Threadfin shad, *Dorosoma petenense,* which had been present in large numbers and provided an important food item for bass since 1967, unexpectedly declined in numbers beginning in 1974; only a few were observed during electrofishing operations in 1975 (6 fish) and 1976 (3 fish).

(2) The number of catchable trout planted at the reservoir annually was increased considerably.

(3) A severe drought, which affected much of California, reduced water levels in late 1975 and in 1976.

(4) Largemouth bass reproduction was below average during most years following 1972; a phenomenon which may have been related to water level manipulations.

It is difficult to relate certain changes in the fishery of Merle Collins Reservoir after 1972 to the size limit because of the complexity of the reservoir environment and because of the abnormal events listed above. Similarly, detection of changes in predator-prey structure is difficult. Census data and observations made during electrofishing operations do not suggest that intermediate-sized panfish were substantially reduced in number. This study has shown, however, that the size limit reduced angler harvest of largemouth bass, a desired result of minimum size limits (Funk 1974). This was accomplished with good public acceptance and without reductions in angler effort or total yield of game fish. Evidence was gathered to indicate that the size limit also protected smallmouth and spotted bass less than 305 mm long. As these findings became apparent, size limits were applied to all black bass at Merle Collins Reservoir and 26 other California waters.

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Robert R. Rawstron initiated and administered the creel census at Merle Collins Reservoir until 1975. Many seasonal aids, too numerous to list, ably served as census clerks during the study period. Charles E. von Geldern, Jr. made helpful editorial suggestions.

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THE STANDING STOCK AND PRODUCTION OF EELGRASS, *ZOSTERA MARINA,* IN HUMBOLDT BAY, CALIFORNIA [1]

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Measurements of the eelgrass, *Zostera marina,* standing stock in Humboldt Bay, California, were conducted on seven occasions from June 1971 through August 1972. The distribution of eelgrass in the Bay was initially determined by mapping the *Zostera* beds in extensive surveys using light aircraft, automobiles, and small boats. Following these preliminary studies, eelgrass samples were periodically taken from representative sites in the eelgrass beds. These studies were performed in an effort to determine the contribution of eelgrass to primary production in Humboldt Bay relative to that of the phytoplankton, and to estimate the annual production of eelgrass by repeated collection of samples throughout the year. Values ranged from 1.4×10^6 kg dry wt in April 1972 to 6.9×10^6 kg dry wt in July 1972. South Humboldt Bay eelgrass accounted for 78 to 95% of the total stock. The area supporting *Z. marina* growth was 12.2×10^6 m^2. Densities of plant biomass ranged from 0.03 to 0.73 kg dry wt/m^2, with highest values recorded for south Humboldt Bay beds. A minimum value for eelgrass production was estimated from the seasonal increase in standing stock and published values for carbon content. Production for the April–July interval was 1.48 g C/m^2/day. Minimum eelgrass production for Humboldt Bay was 18.1×10^6 g C/day. The value for eelgrass production for this interval in Humboldt Bay was similar to that reported for phytoplankton production measured over the same period. This level of primary production is comparable in magnitude on an areal basis to those of highly productive cultivated systems and rich coastal and estuarine regions.

INTRODUCTION

Eelgrass, *Zostera marina,* grows on broad expanses of intertidal mudflats in the two major regions of Humboldt Bay, California (Figure 1). The biomass density and area of coverage are so large as to render the *Zostera* beds one of the most prominent features of the Humboldt Bay estuary. This study is an examination of the eelgrass standing stock and production in Humboldt Bay. Our preliminary studies indicated that changes had occurred both in the density of biomass and the distribution of eelgrass during the 10-year interval since earlier studies were completed (Keller 1963; Keller and Harris 1966). The importance of *Z. marina* to primary production in the Bay prompted further quantitative investigation for comparison with previous studies and for evaluation of the status of the Humboldt Bay eelgrass population.

Zostera marina is an important primary producer in the temperate waters of northern hemisphere estuaries and sheltered embayments. This seagrass com-

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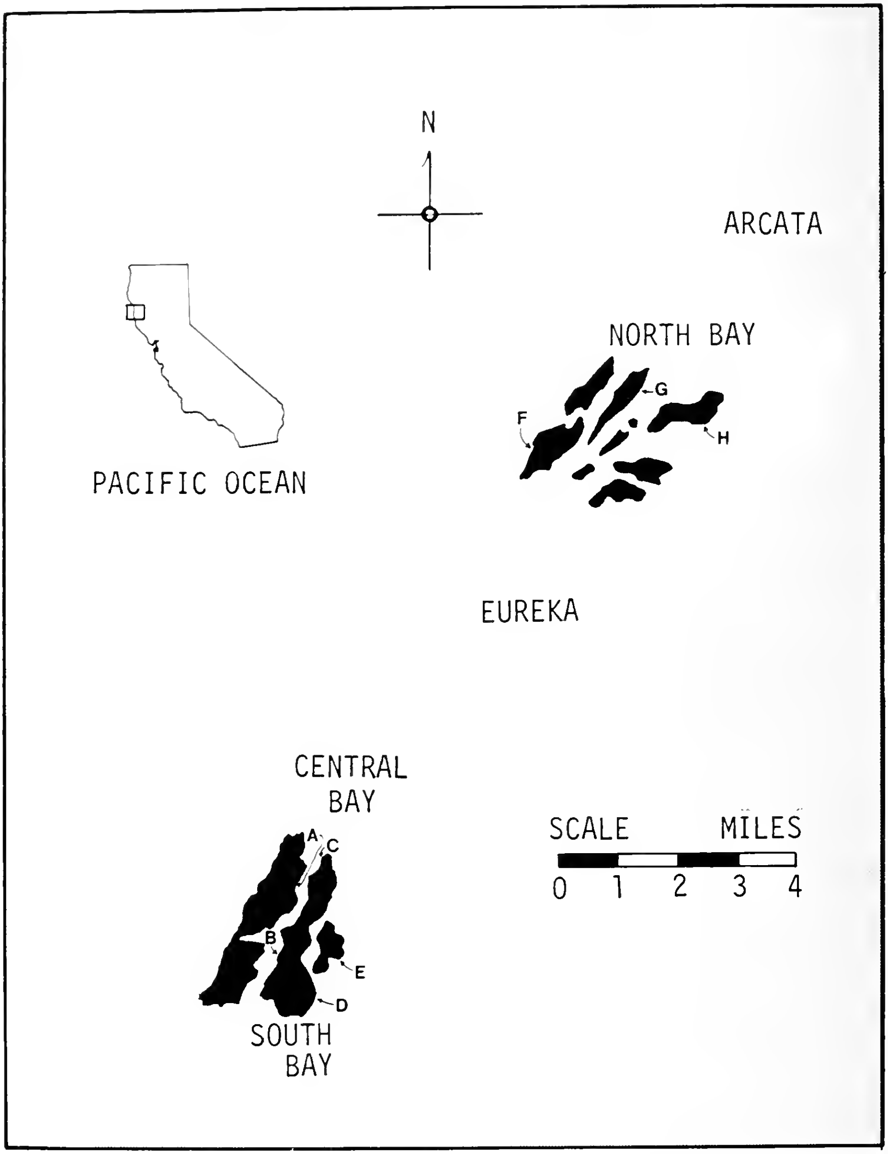

Figure 1. Eelgrass beds and sampling locations in Humboldt Bay, California.

prises the base of a complex food web and provides habitat for a diverse assemblage of associated organisms. Various aspects of eelgrass biology have been discussed before (Peterson and Boysen-Jensen 1911; MacGinitie 1935; Cottam and Munro 1954; Thayer, Wolfe, and Williams 1975). For a complete literature survey on *Z. marina,* consult Phillips (1964) and McRoy and Phillips (1968).

Before 1931, very little attention was given to the populations of this aquatic angiosperm. A sudden decline in eelgrass standing stocks, and the subsequent reduction in commercial fish yields along the eastern seaboard of North America, prompted numerous investigations of community interrelations of *Zostera* (Cottam 1934; Stauffer 1937; Moffitt and Cottam 1941; Dexter 1944, 1953). Peterson (1918) recognized early the economic importance of *Z. marina* as he traced the diet of cod and other commercially important species and suggested that eelgrass formed the autotrophic base of those food chains. Later studies associated with the eelgrass blight emphasized the importance of *Zostera* to the production of mollusks, crustaceans, annelids, and other animal forms. Recent investigations have confirmed the importance of eelgrass as both substratum and habitat for a diverse estuarine flora and fauna (Marsh 1973; Rasmussen 1973).

Aside from its direct participation in marine and estuarine food webs, eelgrass assumes an important role in the cycling of nutrients. Organic materials from natural decomposition processes or sewage effluent are filtered and collected by eelgrass leaves and turions (Milne and Milne 1951), providing an additional nutrient source for the *Zostera* community. Nutrients that otherwise would be accumulated in sediments or flushed out to sea may thereby be retained by eelgrass and recycled within the estuarine system. The functional significance of eelgrass in nutrient cycling and biogeochemistry has been discussed further by McRoy and Barsdate (1970) and McRoy and Goering (1974).

Measurements of eelgrass standing stocks have been conducted throughout the northern hemisphere (McRoy 1970); several of these studies involved eelgrass populations from the west coast of North America. Keller (1963) and Keller and Harris (1966) estimated the distribution and biomass of *Z. marina* in Humboldt Bay. Waddell (1964) studied the effects of oyster dredging on eelgrass standing stocks in Humboldt Bay. McRoy (1966, 1968, 1970) examined the distribution of eelgrass along the coast of Alaska and performed biomass measurements at 10 locations.

Our general approaches in this study involved collecting a temporal series of samples from representative sites in the Humboldt Bay eelgrass beds and determining the areal distribution and density of biomass of eelgrass in the entire Bay. From these data, gathered throughout the year, we hoped to infer the seasonal pattern of growth and decline of the Humboldt Bay eelgrass beds, and to estimate the proportion of primary production attributable to eelgrass in relation to that of the phytoplankton in this estuary.

MATERIALS AND METHODS

Estimation of the total biomass of eelgrass in Humboldt Bay required a twofold approach: (1) determination of the total acreage that supports eelgrass growth in Humboldt Bay, and (2) measurement of eelgrass density at various locations. The product of the area and density of biomass values for each eelgrass bed yielded the total quantity of eelgrass present. Summing these products provided an estimate of the standing stock of Humboldt Bay.

The total area supporting eelgrass was determined during 1971 and 1972. Mapping was conducted on foot and from small boats, automobile, and light aircraft. The boundaries of the eelgrass beds were mapped on a U.S. Geological Survey Chart (No. 5832) of Humboldt Bay. The areas supporting eelgrass growth were determined with a plane planimeter.

Eelgrass beds were subjectively classified according to biomass density as supporting light, medium, or heavy growth. The area supporting eelgrass growth of each density classification was determined and representative sample sites were selected. Five stations in south Humboldt Bay and three in northern Humboldt Bay were chosen for sampling (Figure 1).

Samples were collected over a 2-day period, with north and south Humboldt Bay measurements made on successive days. Similar procedures were employed on seven separate occasions from June 1971 through August 1972. Sampling procedures for the eight representative areas were standardized to eliminate bias in the collection of eelgrass. A 1-m ring thrown in a direction determined by two successive coin tosses defined the area to be sampled; for consistency, the northeast quadrant of the ring was always sampled. Four of the samples (each 0.25 m^2) were collected from each of the eight sites. All plant material within each quadrant was removed, including underground portions, which were carefully collected. The samples were stored in plastic bags and labeled, returned to the laboratory, and kept in a cold room (6 C) prior to processing.

In the laboratory, eelgrass samples were washed to remove sediment from the plant material. Individual samples were subsequently shredded with a knife, placed in tared 800-ml beakers, and weighed (for fresh weight). Samples were then dried at 60 C to constant weight and dry weights determined.

RESULTS AND DISCUSSION

Standing Stock

The total eelgrass standing stock in Humboldt Bay ranged from 1.4×10^6 kg dry wt in April 1972 to 6.9×10^6 kg dry wt in July 1972; south Humboldt Bay eelgrass beds constituted 78 to 95% of the total dry weight (Table 1). The density of plant biomass was consistently higher in south Humboldt Bay than in north Humboldt Bay.

The total eelgrass standing stock for south Humboldt Bay, as determined by Keller and Harris (1966), was lower than the value obtained in this study (Table 2). The difference is partially attributable to the area of coverage considered. Keller and Harris (1966) examined only those mudflats above the -1.5 foot tidal level. Since a considerable portion of the eelgrass population lies below that level, the additional area (about 2.75×10^6 m^2) should have been included in their calculations. They also neglected a significant portion of the plant material, collecting and drying only the eelgrass turions, thereby underestimating the total eelgrass standing stock based on density of biomass measurements. Therefore, our higher values do not necessarily indicate increases in the number or size of eelgrass beds from 1960 to 1972, but may be the result of more complete mapping of subtidal and intertidal areas supporting the growth of *Zostera*, and a more complete sampling of the plant material.

Results obtained by Keller (1963) on the relative biomass per unit area of north and south Humboldt Bay eelgrass were similar to ours. He attributed the differences between the regions to sediment composition, tidal flushing, and the commercial dredging for oysters in north Humboldt Bay. Most mudflats in north Humboldt Bay are lower with respect to tidal height than those in south Humboldt Bay, but it is doubtful that the relationship between tidal height and

TABLE 1. The Densities of Biomass and Standing Stocks of Eelgrass in North and South Humboldt Bay, June 1971 Through August 1972

Date		*No. of samples*	*Density of biomass ($\bar{x}$ ± s.e.) (kg fresh wt/m^2)*	*Density of biomass ($\bar{x}$ ± s.e.) (kg dry wt/m^2)*	*Total (kg fresh wt)*	*Total (kg dry wt)*	*Percent total eelgrass in Bay (dry)*
South Humboldt Bay (area of eelgrass cover = 7.86×10^6 m^2)							
June	1971	12	2.8 ± 1.4	0.21 ± 0.11	22.0×10^6	1.65×10^6	88.3
Dec	1971	20	2.1 ± 1.1	0.32 ± 0.09	16.5×10^6	2.52×10^6	95.1
Apr	1972	19	1.1 ± 0.3	0.14 ± 0.12	8.6×10^6	1.10×10^6	78.3
May	1972	18	1.9 ± 0.5	0.29 ± 0.06	14.9×10^6	2.28×10^6	82.6
June	1972	20	4.7 ± 2.6	0.61 ± 0.40	36.9×10^6	4.79×10^6	90.2
July	1972	20	6.9 ± 3.9	0.73 ± 0.45	54.2×10^6	5.74×10^6	83.1
Aug	1972	20	5.4 ± 3.9	0.60 ± 0.54	42.4×10^6	4.72×10^6	82.5
North Humboldt Bay (area of eelgrass cover = 4.35×10^6 m^2)							
June	1971	12	0.70 ± 0.40	0.05 ± 0.03	3.05×10^6	0.218×10^6	11.7
Dec	1971	12	0.33 ± 0.20	0.03 ± 0.02	1.44×10^6	0.131×10^6	4.9
Apr	1972	12	0.45 ± 0.16	0.07 ± 0.04	1.96×10^6	0.305×10^6	21.7
May	1972	12	0.71 ± 0.09	0.11 ± 0.02	3.09×10^6	0.479×10^6	17.4
June	1972	12	1.0 ± 1.2	0.12 ± 0.11	4.35×10^6	0.522×10^6	9.8
July	1972	12	2.5 ± 2.3	0.27 ± 0.22	10.9×10^6	1.17×10^6	16.9
Aug	1972	12	1.4 ± 1.1	0.23 ± 0.11	6.09×10^6	1.00×10^6	17.5

TABLE 2. Eelgrass Standing Stocks and Mean Biomass Densities from Selected Studies Conducted Along the Western Coast of North America

Location	*Total area (m^2)*	*Total standing stock (kg dry wt)*	*Mean biomass density (kg dry wt/m^2)*
Izembek Lagoon, Alaska (McRoy 1970)	170×10^6	256×10^6	1.52
Kinzaroff Lagoon, Alaska (McRoy 1970)	8.71×10^6	17.0×10^6	1.96
Red Head Lagoon, Alaska (McRoy 1970)	0.45×10^6	0.1×10^6	0.22
Humboldt Bay (Present study)	12.2×10^6	$1.4\text{–}6.9 \times 10^6$ [a]	0.12–0.57 [a]
South Humboldt Bay (Present study)	8.86×10^6	$1.1\text{–}5.7 \times 10^6$ [a]	0.14–0.73 [a]
South Humboldt Bay (Keller and Harris 1966)	5.55×10^6	0.9×10^6	0.16

[a] Range of values for the seven sampling periods in this study

eelgrass biomass density, as proposed by Keller and Harris (1966), contributed much to this difference. The hypothesis does not account for the low eelgrass densities at the −1.0 and −1.5 foot tidal levels. Their results did show that the eelgrass biomass may be more dense at or below the −1.0 foot level at a particular sampling site, but such differences cannot be applied to a comparison of two different locations.

Our values (Table 2) indicate that both the eelgrass standing stock and biomass density in Humboldt Bay are of similar magnitude to those in the Gulf of Alaska lagoons. Previous determinations of standing stock for west coast eelgrass (Keller and Harris 1966; McRoy 1970), however, did not cover a sufficient period of time to permit complete assessment of the populations. Significant fluctuations in standing stock resulting from seasonal influences necessitate the gathering of temporal data. Since samples from the Gulf of Alaska lagoons and the earlier south Humboldt Bay study were taken during the summer months, standing stock values were probably near the annual maxima for the particular study areas. These values can therefore be compared to the higher values obtained in this study.

Eelgrass Production

A minimum value for eelgrass production during the spring and early summer was estimated from the increase in standing stock from April through July 1972. Because losses attributable to herbivore grazing and the physical removal of broken turions were not considered, the estimate is a minimum value for net production; it should not be construed to represent gross production of eelgrass in Humboldt Bay.

The difference in total standing stock between April and July was 5.5×10^6 kg dry wt, representing a mean daily increase of 6.1×10^4 kg dry wt/day. McRoy (1970) used a value of 0.296 g C/g dry wt for estimates of eelgrass production in Alaska, a number which corresponds closely to data gathered by Udell, Zarudsky, and Dohney (1969) in Hempstead estuary on Long Island. With this conversion factor, the change in standing stock and the area of eelgrass coverage, a value of 1.48 g C/m^2/day was calculated for eelgrass production in Humboldt Bay. This is less than McRoy's (1970) value of 8 g C/m^2/day for Izembek Lagoon eelgrass in Alaska, but McRoy's measurements were based on oxygen evolution, not changes in biomass.

Our estimate for eelgrass production is similar to the mean phytoplankton production rate determined for the same period in Humboldt Bay (Table 3), values which are comparable in magnitude to primary production levels in highly productive coastal upwelling (Anderson 1964; Ryther 1969) and estuarine systems (Williams 1966; Taylor and Hughes 1967) which have been studied. These values are also comparable to production figures for *Z. marina* presented by Thayer et al. (1975) and indicate that eelgrass primary production on an areal basis is similar to that of highly productive cultivated crop plants such as corn, rice, and hay (Odum 1959).

TABLE 3. Comparison of Eelgrass and Phytoplankton Production in Humboldt Bay, April Through July 1972

	Area ($m^2 \times 10^6$)	*Mean daily production (gC/m^2/day)*	*Mean total production (gC $\times 10^6$/day)*
Phytoplankton	30.3–65.6	1.05–1.50[a]	32.3–53.4[a]
Eelgrass	12.2	1.48	18.1

[a] Values given are for lower low and higher high water surface areas, respectively (Harding, Cox, and Pequegnat 1978)

The mean daily production of eelgrass in Humboldt Bay was 18.1×10^6 g C/day, and the mean phytoplankton production for Humboldt Bay from April to July 1972 was 32.3×10^6 g C/day for low tide, and 53.4×10^6 g C/day for high tide (Harding, et al. 1978). Because the estimate for eelgrass production is a minimum value, the data indicate that total production by eelgrass was of comparable magnitude to that of the phytoplankton in Humboldt Bay during the spring and early summer of 1972. These data support the conclusion of Williams (1973) that production by seagrasses may equal or exceed that of phytoplankton and contribute substantially to overall production in these rich marine systems.

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ESTIMATING FETUS AGE AND BREEDING AND FAWNING PERIODS IN THE NORTH KINGS RIVER DEER HERD [1]

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Hindfoot length was selected as the best parameter for aging late term California mule deer, *Odocoileus hemionus californicus,* fetuses. Regression analysis indicated that litter size has a bearing on fetal growth. Therefore, aging models were developed for both single and twin fetuses. Estimation of breeding and fawning periods based on fetuses aged by the hindfoot length model showed a 3 week peak of breeding centered on 1 December, and a 3 week fawning period centered on 22 June. The methods described are applicable to any wild deer herd.

INTRODUCTION

Knowledge of the breeding and fawning periods of deer herds is important to management and research. The purpose of this study was to determine breeding and fawning periods of the North Kings River deer herd. In the course of this work we needed to develop a method for estimating the age of late term fetuses.

The North Kings River deer herd is located in Fresno County, California. Other recent studies on this herd have dealt with fawn production and survival (Salwasser, Holl, and Ashcraft 1978) and diets and nutrition during pregnancy (Holl, Salwasser, and Browning 1979).

Breeding and fawning period estimates are often based on the ages of fetuses acquired through special hunts, road kills, and scientific collections (Chattin 1948; Robinette and Gashwiler 1950; Lassen, Ferrel, and Leach 1952; Taber 1953; Bischoff 1957). Most fetal aging studies have relied upon morphological changes during fetal development. Armstrong's (1950) and Hudson and Browman's (1959) keys for whitetailed, *Odocoileus virginianus,* and mule deer, *O. hemionus,* are the basis for this approach. However, as the fetus enters the last trimester of gestation, external changes other than growth are not easily discernible.

Chattin (1948) presented a fetal growth curve based on hindfoot length for fetuses up to 170 days old. Hudson and Browman (1959) provided growth curves for four physical parameters. These were based on five known-age and numerous calculated-age fetuses. Their data terminated at 180 days of fetal age. Short (1970) developed linear regression models for mule deer fetuses from Hudson and Browman's data. Nellis (1966) explored the use of eye lens weights for aging mule deer fetuses. He found the technique useful but pointed out that lens weight was positively correlated with body weight. Only Short (1970) worked with data from fetuses (a sample of three mule deer fetuses) in the last month of prenatal growth. Since much of our work was done during this period we needed to extend aging curves to full-term.

An ideal parameter for aging deer fetuses would have the following character-

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istics: 1) it would change in a predictable and accurately measurable way as the fetus gets older, 2) it would be relatively insensitive to environmental variables, 3) it could be easily and precisely measured by field biologists and researchers alike, and 4) it would require a minimum of laboratory and analytical treatment to derive the age estimate.

Unfortunately, as Verme (1963, 1977) has shown, maternal nutrition affects all easily measured growth parameters of deer fetuses. Thus, while it is conceivable that criteria 1, 3, and 4 could be met, the need for a parameter that is insensitive to environmental conditions is not likely to be met exactly. We thus explored the use of three parameters that we suspected of being the least influenced by maternal nutrition: 1) hindfoot length, 2) contour length, and 3) eye lens weight. Since the eye lens technique requires extra laboratory work, we felt it would have to be far superior to the skeletal growth methods to warrant its use.

METHODS

Deer collections were made during the springs of 1971–1975, as described by Salwasser et al. (1978). Fetuses from each doe were sexed, tagged for identification, and stored in 10% formalin. They were removed from the preservative in the laboratory, rinsed with tap water, and measured.

Contour length was measured with a cloth metric tape to the nearest millimeter. It is the dorsal length of the fetus from the distal edge of the brown nasal patch, along the contour of the head, shoulders and spine to the center point on a line drawn across the ischial tuberosities (see Armstrong 1950). In our attempts to measure crown-rump and forehead-rump lengths of near-term fetuses, we encountered variation due to how the preserved fetus was contorted. This problem could have been avoided by measuring fetuses prior to preservation. We used the contour length because it is less subject to errors that result from deformation of the fetus than are the crown-rump and forehead-rump lengths.

Hindfoot length (HFL) was measured on an "L" shaped device containing a metric ruler on the base. The ankle was placed in the angle of the measuring board, and the length of the hindfoot, to the nearest millimeter, was read at the tip of the hoof. The left hindfoot was measured for standardization. We compensated for hooves damaged during preservation by estimating the length of hoof tips missing.

Eye lenses were removed and rinsed in tap water. (If the fetus has not been in preservative storage, the eyeball should be removed intact and stored in fixative prior to removing the lens.) Lenses were oven dried at 80 C until a constant weight was achieved. Lenses were removed from the oven, allowed to cool for 3–5 minutes, and weighed on a Mettler automatic balance to the nearest 0.01 milligram. Weighing was done within 10 minutes of removal from the oven. Drying time averaged 12 days. Larger lenses required more time than smaller ones. The heavier eye lens was used as the datum for each fetus.

The estimated average size of fawns at birth was calculated from measurements of captured fawns and all fetuses that exceeded the smallest captured fawn in size. We thus assumed that any fetus equal to or larger than the smallest captured fawn was a full-term fetus.

Fetal parameters were regressed on the number of days since 1 November to find the best fit. We had known that all does in the herd bred after this date.

October 1 or 1 September should be used in herds that breed earlier. Regressions were explored for growth differences according to litter size and fetus sex. The influence of doe age is reflected in litter size, as most single fetuses came from yearling and 2-year-old does (Salwasser et al. 1978). Abnormally early- or late-conceived fetuses were excluded form our development of final growth curves. The biological significance of differences in growth equations was judged according to the difference in estimated age at a given size.

RESULTS AND DISCUSSION

The initial fit of all three parameters to the liner model $Y = a + b_x$, was sufficiently good that it was unwarranted to explore transformations or nonlinear models (HFL against days, $r^2 = .859$). This is consistent with the findings of Hudson and Browman (1959), Nellis (1966), and Short (1970) that these are linear growth phenomena in mid- to late-term deer fetuses. All three parameters are suitable for use as aging criteria.

However, hindfoot length is the easiest to measure accurately. Since it also had the best correlation with number of days since 1 November ($r = .94$) (Figure 1), we selected hindfoot length as the best parameter for aging fetuses.

Six fawns, estimated to be from 1 to 3 days old, were captured in 1975. Their average hindfoot length was 237 mm (range 232–246 mm). Their average weight was 3,075 g (range 2,800–3,250 g) (Holl 1976). The smallest captured fawn was the runt of a set of twins. We inferred from the captured fawn data—and from Cowan and Wood (1955); Hudson and Browman (1959); Robinette, Baer, Pillmore and Knittle (1973)—that a single fawn, or one of a set of twins, must exceed 3,000 g to qualify as a full-term fetus. Nine fetuses met this criterion, five singles and two sets of twins. When pooled with the captured fawn data, the estimated average size of a full-term fetus was: HFL = 231 mm (S.D. = 16, range 192–255 mm), weight = 3,254 g (S.D. = 219, range 2,800–3,668 g).

When the estimated average hindfoot length of a newborn fawn was inserted into the regression model for change in hindfoot length of all fetuses since 1 November, an age of 235 days was predicted. We assumed 204 days to be the average gestation period of California mule deer. Dixon (1934) reported 207 days, Robinette and Gashwiler (1950) reported 202 days, and Short (1970) reported 200 days as average gestation periods for the species of *Odocoileus*. Therefore, we adjusted the y-intercept of the model downward by 31 days to yield a predicted age of 204 days when hindfoot length reached 231 mm. It was further assumed that the regression models for other parameters overestimated fetus age by 31 days and adjusted the models for predicting fetal age (Table 1).

TABLE 1. Regression Equations for Predicting Fetus Age from Hindfoot Length, Contour Length, or Eye Lens Weight Regardless of Fetus Sex or Litter Size

n	*Regression equation*	*r*	r^2	*S. E. b.*[1]
151	Age = 68 + .59 (HFL in mm)	.960	.921	.014
151	Age = 45 + .26 (Contour in mm)	.945	.893	.007
106	Age =76 + 1.01 (Lens weight in mg)	.945	.893	.035

[1] S. E. b. is the standard error of the slope coefficient.

The influence of fetal sex and litter size on hindfoot length was examined with the linear regression model (Table 2). Fetal sex apparently had little effect on late-term size (Table 3). Males were slightly larger at 100 days, but size differ-

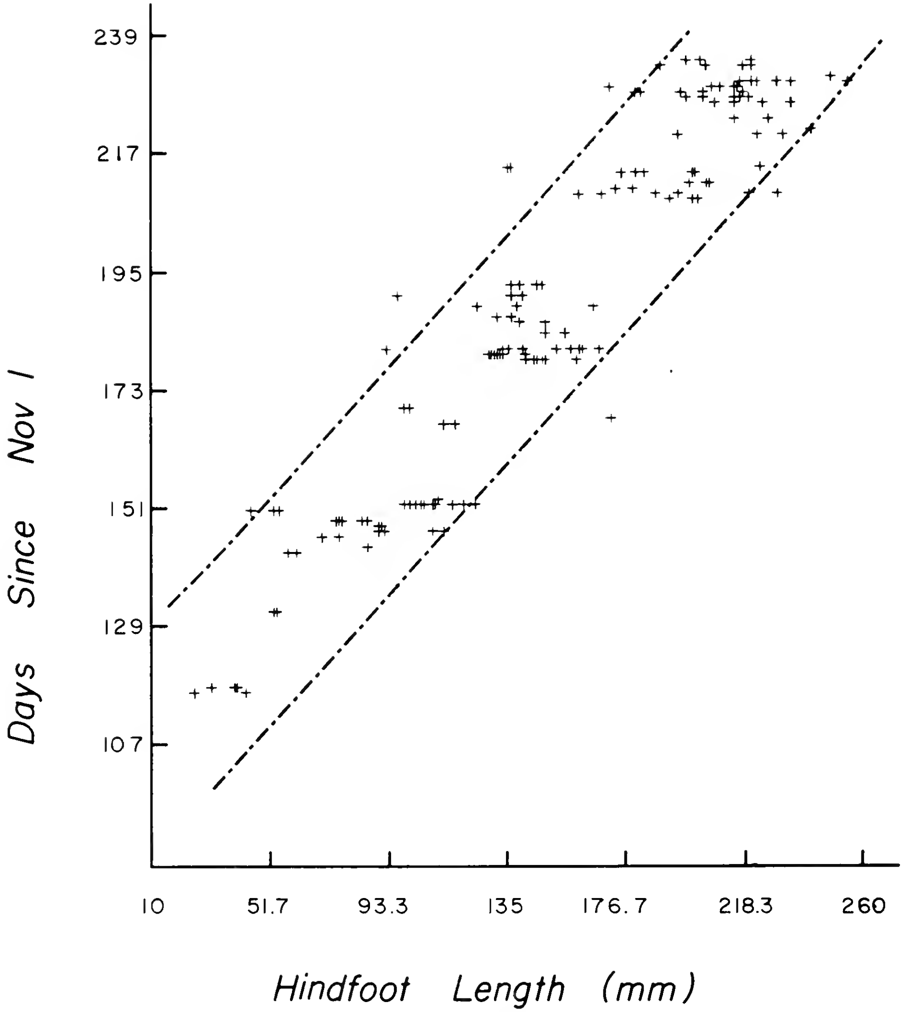

Figure 1. Scattergram of fetal hindfoot length versus number of days since November 1 to date of collection. The dashed line represents a 45-day span and illustrates the linear relationship of hindfoot growth with time.

ences diminished to essentially none at birth. Litter size did make a difference, however. Single fetuses were smaller at 100 days, perhaps reflecting the fact that most singles came from yearling and 2-year-old does that were breeding for the first time. By 200 days, singles exceeded twins by 15 mm in hindfoot length. Until the causes of these differences become known, we advise the use of different aging equations for singles and twins. Since these models were based on fetuses with hindfoot lengths ranging from 50 mm to that at full term, the models are suitable for aging any fetuses over 100 days old (or fetuses from does collected after February in the North Kings herd). Because of environmental variations between years and natural variations between does, the late-term ages derived from the aging equations should be interpreted as being accurate to ± 5 days at best.

TABLE 2. Fetus Sex and Litter Size Influences on Hindfoot Growth

Fetuses	*n*	*Regression equation*	*r*	r^2	*S. E. b.*[1]
All	151	Age = 68 + 59 (HFL in mm)	.960	.921	.014
Males	78	Age = 65 + 60 (HFL in mm)	.960	920	.020
Females	73	Age = 71 + 57 (HFL in mm)	961	925	.019
Singles	28	Age = 75 + 53 (HFL in mm)	.963	.928	.029
Twins	114	Age = 65 + 61 (HFL in mm)	963	928	016

[1] S. E. b. is the standard error of the slope coefficient

TABLE 3. Relative Growth of Fetuses According to Equations Presented in Table 2

Fetuses	*Regression equation*	*Hindfoot length (mm) at*		
		100 days	*150 days*	*200 days*
All	Age = 68 + 59 (HFL in mm)	54	139	224
Males	Age = 65 + 60 (HFL in mm)	58	142	225
Females	Age = 71 + 57 (HFL in mm)	51	139	226
Singles	Age = 75 + 53 (HFL in mm)	47	142	236
Twins	Age = 65 + 61 (HFL in mm)	57	139	221

We believe that the use of a time series analysis of fetal growth with known size of newborn fawns is a suitable alternative in developing fetal age curves when known-age fetuses are not available. Given a time series collection of pregnant does and information on newborn fawn size, a fetal age predictor could be developed for any wild deer herd. Special care should be used, however, in applying the assumptions about length of gestation period and average size of newborn fawns to populations that differ from those reported in the literature. Also the time series method described here should not be used in studies in which fewer than 20 fetuses are available.

To determine breeding and fawning periods, the age of a multiple litter was assumed to be the age of the largest fetus. The age of each litter was extrapolated to determine conception date. Average fawning date was assumed to occur 204 days after the conception date (Figure 2).

The earliest breeding occurred on 6 November (1974), the latest on 3 February (1973), probably during the second or third estrus period. Two-year-old does were involved in both cases. In all other years breeding commenced during the second week of November and terminated during the third week of December. The mean dates of breeding ranged from 25 November (1972) to 10 December (1971). Over the 5-year period, the mean breeding date was 1 December, and 75% of all breeding occurred within 8 days of that date.

Fawning on the North Kings range may begin as early as 29 May, but the first fawns in most years will be born during the first week in June. The peak 2 weeks of fawn drop occur between 14 June and 30 June. Sixty percent of the fawns are born during this period. Approximately one-fourth of the fawns are born in early July. Yearlings and 2-year-old does bred and fawned about 1 week after prime age does.

The breeding and fawning periods of the North Kings herd are earlier than those reported for the Sequoia and Jawbone herds on the Sierra Nevada west slope (Bischoff 1957). The periods are similar to those of some black-tailed deer, *O. h. columbianus,* herds in California.

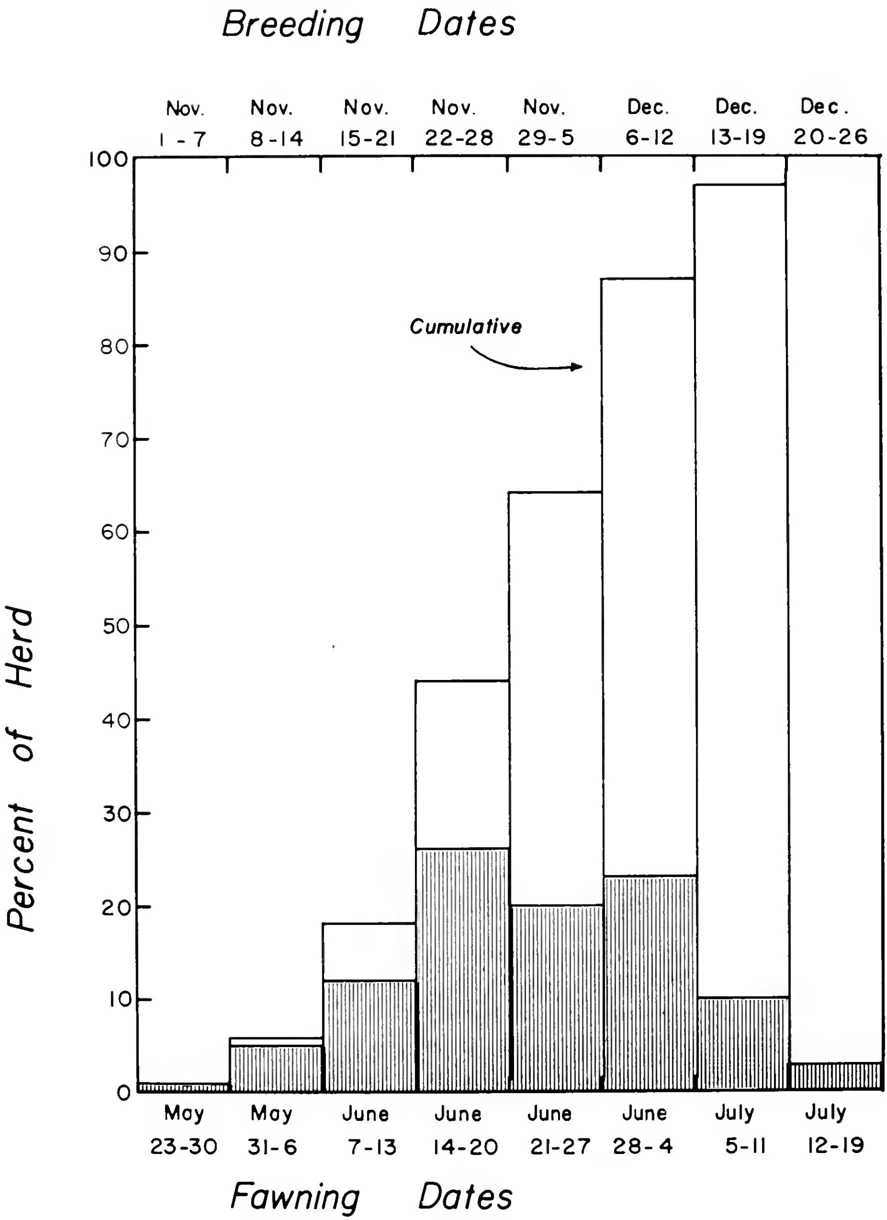

Figure 2. Bar histogram of conception and breeding dates of California mule deer in the North Kings River herd during 1971–75.

ACKNOWLEDGMENTS

We are pleased to acknowledge the assistance and advice of Oscar Brunetti, William Longhurst, Guy Connolly, and Karen Shimamoto. John Kie offered valuable comments. Nobu Asami of U.C. Berkeley prepared the manuscript.

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NOTES

HEMATOLOGICAL STRESS RESPONSE OF RAINBOW TROUT, *Salmo gairdneri,* TO A SIMULATED GEOTHERMAL STEAM CONDENSATE SPILL

Steam condensate is a by-product of electrical power production using geothermal steam at the Geysers, Sonoma County, California. The condensate is ordinarily returned to the production zone by reinjection well, but during 1974 and 1975 eleven major spills occurred in which the condensate reached nearby streams. Although fish kills resulted from some of these spills (Department of Fish and Game unpublished data), the sublethal effects of the condensate remain undocumented.

Blood hematology has been used by some researchers to monitor sublethal stress response of rainbow trout (Blaxhall 1972, Courtois 1975, McLeay 1975). This study was undertaken to determine if hematological characteristics of rainbow trout are affected after exposure to stream condensate under simulated stream conditions.

At condensate concentrations of 5 to 29%, LeGore and Bowen (1976) found 50% of the rainbow trout died within 96 hours. During low flow (5 cfs) periods in streams adjacent to the Geysers, large spills of condensate (e.g., 182,000 liters in 4 min on September 5, 1975) could exceed these concentrations. The condensate would be gradually diluted and carried downstream. Little is known about the degree of stress placed upon fish exposed to spills of condensate at low concentrations. Monitoring the hematological stress response of rainbow trout to the condensate would be valuable in assessing its effect on fish in their natural habitat.

To approximate a condensate spill, 56.8 liters of condensate, collected from Geysers Power Plant Unit 6 was added to a 500-liter tank containing 378.5 liters of filtered river water and 20 shasta strain rainbow trout from the American River Fish Hatchery averaging 114 g wet weight and 22 cm FL. This represented a 15% volume/volume addition to a stream. The added condensate slowly overflowed through a standpipe drain which kept the water level constant. An identical tank with 20 fish served as an untreated control group. Water in both tanks was exchanged at the rate of 60 liters/hr. Air was bubbled in the tanks through porous stones. Carbon dioxide, ammonia, and oxygen levels were monitored in each tank using Hach$^{(R)}$ prepared reagents. These parameters were altered when steam condensate was added to water in preliminary tests.

Blood from fish in both the control and test tanks was collected immediately after beginning the test and at 2 hr, 23 hr, and 93 hr. Individual fish were used only once during the test and were not returned to the test tank. Five fish from each tank were anesthetized with MS-222 (tricaine menthanesulfonate), and a heparinized syringe was used to remove a blood sample via cardiac puncture. Hematocrit (PCV) and total hemoglobin (Hb) (cyanmethemoglobin form) levels were established using standard techniques (Blaxhall 1972) and serum protein values were determined with a hand refractometer (Courtois 1975, 1976; Schalm 1975).

Extreme physiological differences were evident between control fish and test fish blood parameters, during these tests. This indicates that even small concentrations of geothermal steam condensate will stress rainbow trout.

Amounts of ammonia (30 mg/l) and carbon dioxide (90 mg/l) were very high up to 23 hr after addition of the condensate but had returned to pre-test levels by 93 hr. Dissolved oxygen decreased by 1.0 ppm following introduction of condensate but returned to the control level for the remainder of the test period. These features of condensate may cause the most stress for fish populations during a spill.

The mean corpuscular hemoglobin concentration (MCHC) is a sensitive indicator of stress in fish and was determined using hematocrit and hemoglobin values MCHC = Hb/PCV (100) (Schalm 1975). MCHC increased sharply (+1.5 g/100 ml) following addition of the condensate, dropped below normal (−1.3 g/100 ml) and then remained significantly (95% confidence level) above control values (+3.4 g/100 ml) for the duration of the test, indicating an increase in mobilization of new blood cells from storage locations. This is a typical response to a stressful situation.

Hatchery-raised fish were used because of their resistance to the stress of handling but this increased tolerance may have dampened response results. Stress response of rainbow trout over a longer term is not known and would be of interest.

Doudoroff and Katz (1953) have shown that sublethal pollution can alter the size and structure of wild fish populations. This preliminary study indicates that spills of geothermal steam condensate into small streams will influence wild populations of rainbow trout.

ACKNOWLEDGMENT

We gratefully acknowledge the assistance and space provided by the Water Pollution Control Laboratory, California Department of Fish and Game, Rancho Cordova, CA, for this experiment.

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OBSERVATIONS OF FINGERLING CHINOOK SALMON IN THE STOMACHS OF YELLOW PERCH FROM THE KLAMATH RIVER, CALIFORNIA

In a study to determine the relationship between yellow perch *(Perca flavescens)* and young salmonids, Coots (1956) examined the stomachs of 731 perch collected from March 1951 through March 1952 from the Klamath River in California and found no salmonids. Additional perch stomachs were examined during a trapping operation for downstream migrant chinook salmon *(Oncorhynchus tshawytscha)* fingerlings in February, March, and April 1952, but salmonids were not noted in their stomachs.

Under artificial conditions in live traps and aquarium tests with adult perch and fingerling salmon, Coots (1956) found that perch would eat the salmon if given the opportunity.

On 7 May 1976, the stomachs of 44 yellow perch taken from the Klamath River were examined for the presence of fingerling chinook salmon. These samples were collected from the Klamath River in Siskiyou County about 100 m downstream from the mouth of Bogus Creek just below the Iron Gate Fish Hatchery. They were taken in slack water near a brushy bank with a boat-mounted electrofisher.

Fingerling chinook salmon were found in 35 (80%) of the perch stomachs. Each of these stomachs contained one to five salmon, 3.2 to 4.4 cm fork length (FL). The average length of yellow perch with chinook salmon in their stomachs was 15.0 cm FL with a range of 12.2 to 19.8 cm FL.

At times, yellow perch and fingerling salmon apparently utilize the slack water area where the perch were captured, thus providing the opportunity for perch to prey on young salmon. If there were extensive areas with the proper conditions, perch predation on salmon fingerlings could be an important factor in salmon survival.

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AN ABNORMALLY PIGMENTED SHORTSPINE THORNYHEAD, *SEBASTOLOBUS ALASCANUS* BEAN

On April 17, 1975 a black shortspine thornyhead was caught by the trawler *Helen Louise* while fishing off Coos Bay, Oregon, in about 300 fm. The striking color abnormality was brought to my attention by skipper Tom McDonald and his crewman.

The entire fish was darkly pigmented, closely resembling the coloration of a sablefish, *Anoplopoma fimbria.* It was landed with about 2200 kg of normally pigmented (red) shortspine thornyheads. It was a female 452 mm total length, in excellent condition. This is the only such color abnormality I have observed for this species in over 6 years of sampling trawl catches in the Newport–Brookings, Oregon area.

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A JUVENILE OCEAN TRIGGERFISH, *CANTHIDERMIS MACULATUS* (BLOCH), (PISCES, BALISTIDAE) FROM THE GULF OF CALIFORNIA

On 20 August 1972, while dipnetting juvenile fishes at the docks inside San Carlos Bay, Sonora, Mexico, I collected an ocean or rough triggerfish, 12.8 mm standard length (SL). The fish was swimming under a small raft of seaweed, *Sargassum* sp, in the company of a clinid, *Exerpes asper,* which is locally abundant in the *Sargassum* habitat. The distinctively low meristic counts (D. III, 23; A. 20; P_1. 14) were within the ranges presented by Berry and Baldwin (1966), and the general body form agreed with their illustration. However, the pectoral fins were more lobed than they showed, the upper rays being four times the length of the lower rays.

Canthidermis maculatus has a circumtropical distribution, being found both inshore (rarely) and in surface waters of the open ocean. It is the most wide-ranging and probably the most abundant triggerfish in the eastern Pacific, where it has been reported from Haucho, Peru, to waters off central Mexico (Berry and Baldwin 1966). Of the six triggerfishes reported from the eastern Pacific by Berry and Baldwin (1966), three are residents in the Gulf of California: *Balistes polylepis* Steindachner, *Pseudobalistes naufragium* (Jordan and Starks), and *Sufflamen verres* (Gilbert and Starks). The addition of *Alutera scripta* (Osbeck), sometimes placed in the family Monacanthidae, raised the total to four (Boyd W. Walker, pers. commun.). My triggerfish is the fifth balistid recorded from the Gulf of California.

From 28 June to 21 July 1972, I collected about 2,750 juvenile fishes of approximately 40 species, in association with floating mats of *Sargassum* (Behrstock 1975). The collecting was done just outside the mouth of San Carlos Bay, about 1 km from the *Canthidermis maculatus* collection site. My samples included 20 juveniles of the finescale triggerfish, *Balistes polylepis,* a common species in the Gulf of California. Although most of the species I collected probably have spawning populations in the vicinity of San Carlos Bay, some, such as *Canthidermis maculatus,* may have been swept up the east side of the Gulf by the southerly winds which predominate during the summer (Roden 1958; Roden and Groves 1959) and represent expatriates from Pacific Ocean populations.

ACKNOWLEDGMENTS

For their comments on the distribution of triggerfishes and/or locality data for specimens under their care I would like to thank: Boyd W. Walker and Robert R. Harwood, University of California, Los Angeles; Richard H. Rosenblatt, Scripps Institution of Oceanography; Matthew R. Gilligan, University of Arizona; and John E. Fitch, California Department of Fish and Game. Permission to collect fishes in Mexican waters (Permit No. 4995) was secured through the office of the Secretaria de Industria y Comercio, Subsecretaria de Pesca, Direccion General de Regiones Pesqueras, Mexico City, Mexico. Also, I'd like to thank Gary Friedrichsen of Arcata, California, for providing transportation and stimulating conversation on a most worthwhile field trip.

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A PACU (*COLOSSOMA,* FAMILY CHARACIDAE) CAUGHT IN THE SACRAMENTO RIVER

On 10 October 1977, a piranha-like fish was caught by 16-year old Jimmy Seidel of Sacramento, while fishing for catfish using a hook baited with an earthworm. The fish was caught on the Yolo County side of the Sacramento River near Elkhorn Ferry just above Sacramento. Reports that the fish was an illegal piranha led to its seizure by the Department of Fish and Game for identification. The frozen specimen was identified by the senior author as a pacu, a largely vegetarian characin of the genus *Colossoma.* (Figure 1) The fish was thawed, measurements and counts made, scale samples taken, and the gut removed; the stomach and intestine were empty, the lumen of minimum diameter.

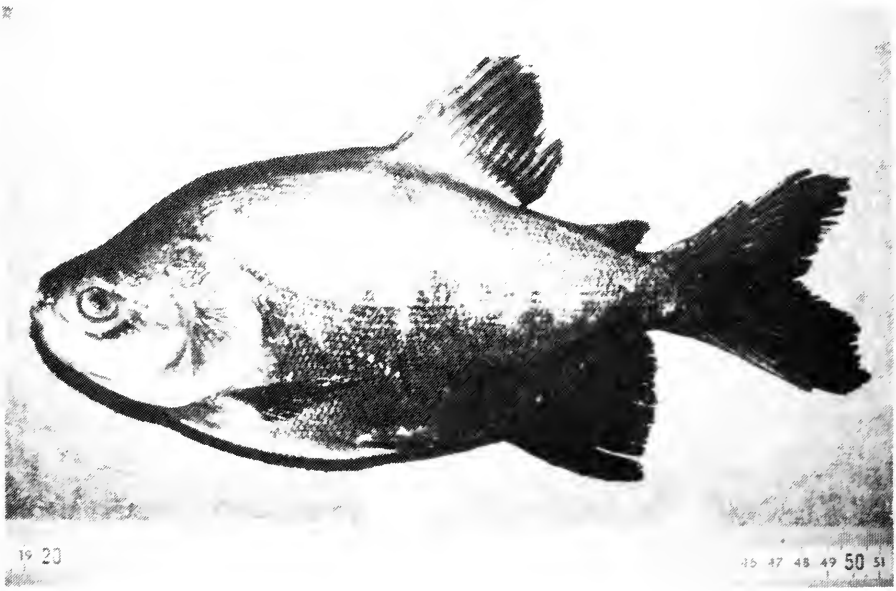

Figure 1. A pacu, *Colossoma nigripinnus,* 332 mm. total length, caught in the Sacramento River, October 10, 1977. *Photograph by Martin R. Brittan.*

The fish was a subadult male of 332 mm TL, 294 mm FL, 255 mm SL, having lost the spotted and barred juvenile pattern characteristic of *Colossoma* up to about 150 mm SL and attained the adult coloration, in which the back is silver-black, the underside of the head and anterior belly pinkish-orange (turning silvery after death), and the rest of the body blackish, except for the brownish opercle. The silvery-black back and the blackish lower flanks are delineated by an irregular "zig-zag" wash (see photo). The greatest body depth is 120 mm (47% of SL), head length 88 mm (34% of SL), orbit 15 mm (17% of head length), predorsal distance 148 mm (58% of SL), preanal distance 185 mm (73% of SL), prepelvic distance 132 mm (52% of SL). There are 90 to 95 scales in the lateral line (about 10 on the caudal base); transverse line about 25 scales from dorsal to lateral line and 24 from lateral line to midbelly; predorsal scales about 47; about 25 midventral serrae to origin of ventrals plus 26 to anus; 8–9 rows of ventral sheath scales. Dorsal iv,14; anal iv,22; pectoral i,17. Teeth in upper jaw in two rows, the 10 in the outer row with an outer incisiform edge, the central teeth with dark tips. The six teeth in the inner row have an inner and outer incisive edge (not so sharp as that of the outer teeth) with a shallow concavity between. (Figure 2) The teeth in the lower jaw total 12 in a single row, becoming progressively smaller and simpler, the center ones incisorlike, the lateral ones becoming conical. (Figure 3) The opercle and subopercle exhibit posteriorly-diverging radiating striae.

Figure 2. Head of pacu, showing upper dentition and fleshy, flap-like lower lip. *Photograph by Martin R. Brittan.*

Figure 3. Lower dentition of pacu. *Photograph by Martin R. Brittan.*

The original descriptions of the six nominal species, mostly dating from the early and middle 19th century, are sketchy and based on one or only a few specimens. There have been no recent revisions of the genus and scientific specimens are few, although *Colossoma* are common food fishes in tropical fresh waters of South America. The specimen closely compares to some in the California Academy of Sciences identified by Stanley W. Weitzman and William I. Follett as *Colossoma nigripinnus* Cope. Specimens identified as *Colossoma bidens* had much smaller scales. The senior author tentatively identified the Sacramento specimen as *C. nigripinnus.*

The specimen showed no evidence of disease or parasites. How long it had been in the river is not known, but since pacus and piranhas are generally sympatric and have comparable ecological requirements, some deductions can be made. Temperatures in the Sacramento River were unusually high during summer 1977, a drought year, and between mid-May and mid-October were above 18 C which is approximately the minimum temperature at which most tropical lowland fishes can maintain themselves. Temperatures at which such fishes could comfortably exist occurred between mid-June and mid-September: June 28, 25.1 C; July 28, 24.8 C; August 8, 25.0 C; September 13, 23.3 C. The higher temperatures are within breeding range. During most years midsummer temperatures average about 20–21 C, and in some years run as low as 17–18 C. Mid-winter temperatures range from 6.5 to 9.0 C and would be lethal. Evidence that the fish did not over-winter comes from the scales, which exhibited no growth rings or stress checks.

Gery (1973) and Sterba (1962) give maximum lengths of 60–80 cm and a weight of 10 kg for *Colossoma.* Lovshin, et al. (1974) report seeing the larger pacus, called tambaqui, reaching a maximum length of 89 cm and a weight of over 13 kg in the Manaus, Brazil, market; they also report that fishermen say tambaqui exceed 20 kg. *Colossoma* grow rapidly in sufficiently roomy aquaria, as much as an inch a month. They are frequently a problem when they outgrow an aquarium. Our specimen was probably released into the river sometime after early June, probably a few days before being caught, in view of the empty digestive tract, since there is considerable algae and vegetable debris in the river. It is unlikely that this species or others with the same temperature requirements could overwinter in Northern California waters. However, any new hot water discharge into natural waters should be considered to be capable of creating survival and/or reproductive conditions.

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EFFECT OF FIRST PECTORAL FIN RAY REMOVAL ON SURVIVAL AND ESTIMATED HARVEST RATE OF WHITE STURGEON IN THE SACRAMENTO-SAN JOAQUIN ESTUARY

INTRODUCTION

Sturgeon ages commonly are estimated from annual growth patterns in cross sections of the first, or anterior, ray of the pectoral fin. However, removal of fin rays during a tagging study may affect survival of the fish and bias estimates of population parameters estimated from tag recoveries. Several authors have released sturgeon after removal of the anterior pectoral fin ray without discussing the effect on subsequent survival (Cuerrier and Roussow 1951; Pycha 1956; Priegel 1973). Bajkov (1949) stated that white sturgeon *(Acipenser transmontanus)* appear to withstand removal of a fin ray without any damage, but offered no evidence for his conclusions.

To determine the effect of pectoral fin ray removal on survival and estimated harvest rate of white sturgeon, I evaluated tag returns from the Sacramento-San Joaquin Estuary, California.

METHODS

In fall 1974 sturgeon were captured with trammel nets in San Pablo Bay and tagged with disc dangler tags placed beneath the anterior part of the dorsal fin. Capture and tagging methods have previously been described (Chadwick 1963; Miller 1972). Five dollar reward tags were used exclusively to assure a high rate of angler response.

To determine the age composition of tagged fish, the first ray of the left pectoral fin was removed from every second sturgeon tagged. Prior to tagging, the fish was placed on its right side on the boat deck and the fin ray was severed as close to its articulation as possible. Large cutting pliers or a small hand saw were used to cut the ray. This procedure required less than 1 minute per fish. To facilitate analysis, fin rays were removed only from fish with odd numbered tags. For convenience, I will refer to fish with the fin ray removed as odd numbered and those with intact pectoral fins as even numbered.

Harvest rates were calculated from first year returns of each tag type. Confidence limits for harvest rates were estimated assuming tag returns followed a Poisson distribution.

I analyzed 3 years of tag returns to determine the effect of pectoral fin ray removal. Returns of odd and even numbered tags were compared using a standard chi-square test of independence (Sokal and Rohlf 1969). Mortality due only to fin ray removal was estimated as: 1—ratio of odd:even tag return percentages. I estimated survival separately for odd and even numbered tags using a linear regression of logarithm of returns against time (Ricker 1975). The antilogarithm of the slope of the regression line is an estimate of annual survival.

RESULTS AND DISCUSSION

A total of 712 legal sized (≥ 101.6 cm total length) white sturgeon was tagged in 1974. Of those, 358 had the first ray of the left pectoral fin removed and 354 did not.

The tag returns indicate fin ray removal caused mortality (Table 1). During the first year, 13 odd numbered and 20 even numbered tags were returned, yielding harvest rate estimates of 0.036 and 0.056, respectively. The respective 95% confidence intervals were 0.019–0.060 and 0.036–0.085. While the difference in these return rates was not statistically significant, the difference was significant at the end of 2 ($X^2 = 5.24$, $P < 0.025$) and 3 ($X^2 = 8.20$, $P < 0.005$) years due to continued higher returns of even numbered tags.

The decrease in the ratio of odd:even tag return percentages was relatively small after the first year, indicating that most mortality due to fin ray removal occurred in the first year. However, the fact that this ratio did decrease suggests some mortality occurred during the second year also (Table 1).

After the first year, estimated annual survival of odd numbered sturgeon was 0.88 and estimated survival of even numbered fish was 0.95 (Figure 1). These estimates are imprecise since return sample sizes are small and the points do not fall in a straight line.

I conclude that removing the first ray of the pectoral fin of white sturgeon causes substantial mortality during the first year and less mortality thereafter. Also, consistently greater returns of even number tags in all 3 years indicates that mortality from pectoral fin ray removal results in an underestimate of exploitation and that the best estimate of exploitation rate is based on even numbered tags alone. If fin ray removal is used in conjunction with a sturgeon tagging program, estimates of population parameters derived from tag recoveries may exhibit serious bias.

TABLE 1. **Tags Received During the First 3 Return Years from White Sturgeon Tagged in San Pablo Bay in Fall 1974. Odd numbered tags are from fish with the primary ray of the left pectoral fin removed for age determination. Even numbered tags are from fish without fin ray removal.**

Return year	*Odd tags returned*		*Even tags returned*		*Total returns*	*Ratio odd/even percentages*	*Mortality due to fin ray removal (1 – ratio odd/even percentages)*	*Estimated annual mortality increment due to fin ray removal*
	Number	*Percent*	*Number*	*Percent*				
1974–75	13	3.6	20	5.6	33	0.64	0.36	0.36
1975–76	10	2.8	20	5.6	30	0.50	0.50	0.14
1976–77	10	2.8	18	5.1	28	0.55	0.45	–0.05
Total	33	9.2	58	16.4	91	0.56		

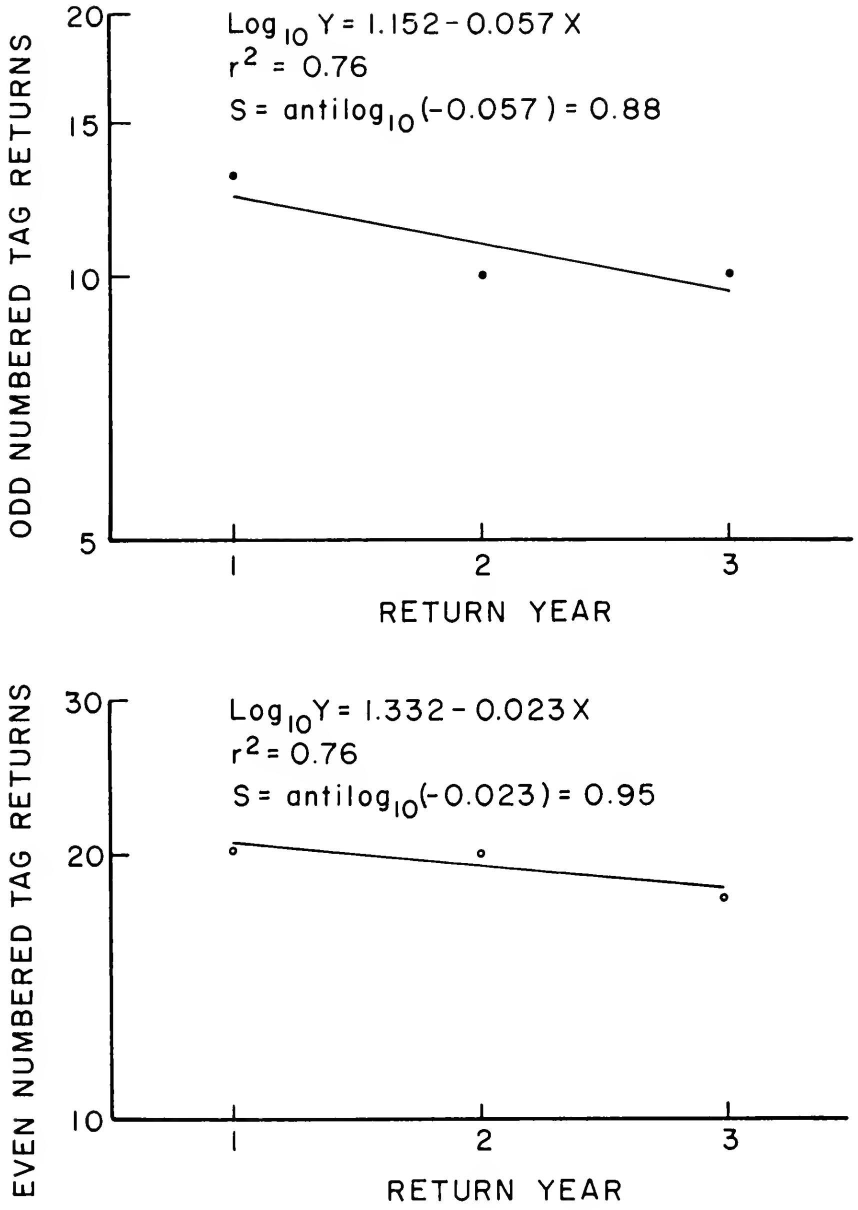

FIGURE 1. Tag returns from white sturgeon tagged in San Pablo Bay in fall 1974. The antilogarithm of slope is an estimate of annual survival rate (S). Slope and survival are calculated separately for odd numbered fish with the first ray of the left pectoral fin removed (a) and even numbered fish with no fin ray removed (b).

ACKNOWLEDGMENTS

Richard Fenner and Salvatore Mercurio assisted in the tagging operation and Donald Stevens reviewed the manuscript. I thank these individuals for their help. 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.

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EVIDENCE OF SUCCESSFUL REPRODUCTION OF STEELHEAD RAINBOW TROUT, *SALMO GAIRDNERI GAIRDNERI*, IN THE VENTURA RIVER, CALIFORNIA

In recent years there have been scattered reports of adult steelhead trout being caught in the Ventura River, Ventura County, fish which could be remnants of a run that once numbered 4–5,000 adults (Clanton and Jarvis 1946). The question has remained, however, whether these fish were strays from other river systems or whether they could be progeny of successful steelhead reproduction in the Ventura River (Mark Capelli, Friends of the Ventura River, pers. commun.). This note briefly describes a useful technique for identifying juvenile steelhead and provides data supporting their presence in the Ventura River.

Rybock, Horton, and Fessler (1975) showed that steelhead trout juveniles can be distinguished from resident rainbow trout on the basis of otolith nuclei (ON) dimensions. Since spawning steelhead trout females are substantially larger than spawning resident rainbow trout females and have larger eggs and emergent larvae, the earliest formed otolith morphological mark (the ON, or metamorphic check) has a larger width and length in steelhead trout than in resident rainbow trout. Statistically significant differences between the ON size distributions of different samples indicate the existence of distinct fish populations.

Nine dorsal fin clipped juvenile steelhead trout and 11 wild rainbow trout were captured on February 16, 1977 by electroshocking a stretch of the middle Ventura River 10.5–12.9 km above the mouth. The marked steelhead trout were survivors of a July 1976 plant of 11,000 fingerlings. An additional seven unmarked rainbow trout were captured in the upper Ventura River (22.6 km above the mouth) on February 17, 1977. This location is above Robles Diversion Dam, completed in 1959, which prevents upstream migration of fish under most flow conditions.

Otoliths were removed, stored in 100% glycerin, and measured using an ocular microscope (see McKern, Horton, and Koski 1974 and Rybock et al. 1975 for details of the procedure).

Despite clearing in glycerin, 20% (11/54) of the otoliths were unreadable. All but two fish, however, had at least one readable otolith. ON measurements recorded for the Ventura River trout were within resident and steelhead trout ON width and length ranges reported from other Pacific coastal streams (McKern et al. 1974, Rybock et al. 1975). Only ON widths were consistently distinct enough to accurately measure in all readable otoliths.

The comparison of ON widths showed distinct distributions for unmarked trout taken from above Robles Diversion Dam and marked steelhead trout taken from the middle Ventura River (Figures 1*a* and 1*c*). The ON width distribution for unmarked trout taken from the middle Ventura River, however, spanned nearly the entire range of both marked and unmarked trout (Figure 1*b*). Differences in the mean ON widths of the three groups were analyzed by the "t" test for small samples (Alder and Roessler 1968). The differences between the

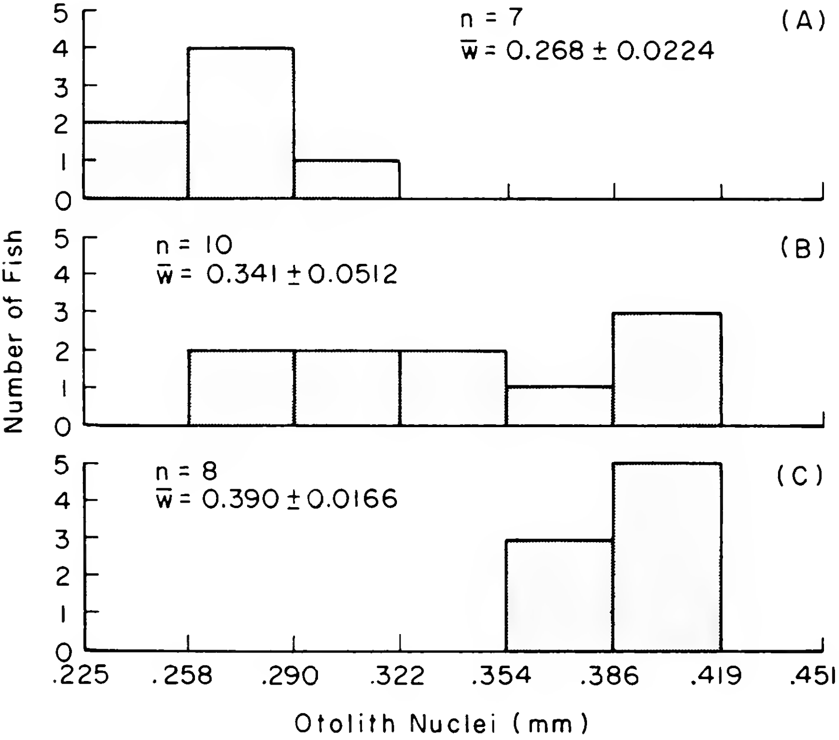

Figure 1. Frequency distributions and means (± 1 S.D.) of ON widths (millimeters) representing: (A) unmarked rainbow trout above Robles Diversion Dam, Ventura River, (B) unmarked rainbow trout from below Robles Diversion Dam, and (C) marked steelhead rainbow trout from below Robles Diversion Dam.

means were all significant ($p < 0.05$), particularly between the trout collected above Robles Diversion Dam and the marked steelhead ($p < 0.001$).

Unmarked trout captured in the middle Ventura River included fish having ON widths within the resident rainbow trout and steelhead trout ranges. The former group is either wild resident rainbow trout or planted rainbow trout that have moved downstream from the Department of Fish and Game catchable trout release sites 25 to 32 km above the mouth. The latter group is either wild steelhead trout or hatchery steelhead trout with regenerated dorsal fins. Since the marked steelhead were dorsal fin clipped only 8 months prior to the study, it is unlikely that they would be misidentified.

The existence of wild steelhead trout juveniles, as judged by the otolith results, implies that some natural spawning and subsequent adult return occurs in the river. However, many questions concerning these fish remain: (i) what percentage of the adult steelhead entering the Ventura River originate elsewhere, (ii) what is the proportion of steelhead trout in the rainbow trout population below the diversion dam, (iii) do any steelhead trout pass the diversion dam and spawn in the upper river, and (iv) what can be done to more effectively protect and enhance the natural steelhead trout run?

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Don Kelley, L. B. Boydstun (California Department of Fish and Game), Mark Moore, and Linda Hagen assisted in collecting the fish. Special thanks go to Don Kelley who provided the collecting equipment and reviewed the manuscript. Mark Moore and Mark Capelli also reviewed the manuscript.

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NOTES ON A HYBRIDIZATION EXPERIMENT BETWEEN RAINBOW AND GOLDEN TROUT

In an earlier note (Gold, Pipkin, and Gall 1976), we presented the results of a fortuitous hybridization experiment between a rainbow trout, *Salmo gairdneri,* female and a golden trout *Salmo aguabonita* male. The hatch and developmental data from that cross were limited, but supported field observations that hybridization between the two species could occur with ease (Dill 1950; Schreck and Behnke 1971; Gold and Gall 1975). This note is a follow-up on that cross.

By 7 May 1975, only one of the six RT x GT hybrid fingerlings remained alive, the rest having succumbed to *Chondrococcus columnaris* infection or gill disease. On 31 December 1976, the survivor, a 2-year-old female, was stripped of

641 normal-sized eggs. These were divided into four lots of roughly 160 eggs each and fertilized with the sperm of four 2-year-old males from the domesticated rainbow trout strain RTD (Gall 1975). The males were 3 months past their spawning peak, but when examined had numerous motile sperm. No golden trout males were available for the complementary backcross. The four lots of fertilized eggs were water hardened and incubated in separate chambers of a Heath-Tecna incubator. Water temperatures during incubation ranged from 9–13 C (median = 11 C). At this temperature, RTD eggs normally eye-up within 13 days and hatch within 29 days (Gall and Pipkin, unpublished data).

None of the backcross embryos developed normally. After 17 days, roughly 80% of the eggs showed no indication of embryonic development. The remainder displayed a single, large, dark spot (not a true "eye") accompanied by several hemorrhagic streaks. Some of these "spots" grew larger, but by 6 February none of the embryos had hatched. On 15 February all embryos had ceased development and were discarded. A systems failure at the Davis hatchery on 16 June 1976 resulted in the death of the hybrid female.

Meristic and morphometric data from the hybrid are compared with mean values for rainbow and golden trout from our unpublished data (Table 1). Hybrid indices computed after Hubbs and Juronuma (1942) were intermediate (.16–.83) for 8 of 27 characteristics.

Life colors of the hybrid were more or less typical of *S. aguabonita* (Evermann 1905), although much less pronounced. Parr-type marks, typical of adult *S. aguabonita* but not adult *S. gairdneri,* were not present. The dorsal, caudal, and adipose fins were moderately spotted, but the body was almost immaculate (Figure 1). Approximately 20–25 small spots, crescent-shaped and diffuse as in *S. gairdneri,* were present on the dorsal region of the caudal peduncle, posterior to the adipose fin. The parents of the hybrid, *S. gairdneri* (♀) and *S. aguabonita* (♂), were heavily and moderately spotted, respectively. The paucity of spots on the body of the hybrid was suggestive of the pattern typical of the Paiute cutthroat trout (Ryan and Nicola 1976).

Data indicative of interspecific hybridization among western trouts are abundant, and have stemmed by-in-large from field studies where one species was introduced (by man) into waters occupied by a second species (e.g. Schreck and Behnke 1971; Behnke 1972; Gold and Gall 1975). As a result, it has been generally assumed that reproductive isolating mechanisms among most western trouts are less than complete, and that forced sympatry will usually result in introgressive hybridization. The sympatric coastal cutthroat, *S. clarki clarki,* and anadromous rainbow trout, *S gairdneri,* are among the few cited exceptions (Behnke 1972). Miller (1972), however, has pointed out that there is little if any experimental data on western trouts regarding mating discrimination or fertility of hybrids.

The failure to obtain backcross progeny from the RT x GT hybrid female may reflect a barrier to hybridization between the two species. The experimental conditions under which the backcross was made were far superior to those of the original parental cross, and there was partial embryogenesis in about 20% of the fertilized eggs. It is conceivable that "hybrid breakdown" (Dobzhansky 1970) was the cause of embryonic mortality, and that reproductive isolating

TABLE 1. Morphological Data † of RT x GT Hybrid, *Salmo gairdneri,* and *Salmo aguabonita*

Character	*Hybrid (n = 1)*	*Salmo gairdneri (n = 20)*	*Salmo aguabonita (n = 32)*
Standard length, cm	26.9	21.4	10.4
Pyloric caecae	43*	59.6	33.3
Dorsal fin rays	11	12.3	12.1
Anal fin rays	11*	11.3	10.7
Pectoral fin rays	16	14.6	15.7
Pelvic fin rays	9	10.1	9.0
Branchiostegal rays (total)	22	22.0	23.9
Gill rakers (left)	18	18.8	19.9
Vertebrae	62*	62.5	60.0
Scales, lateral line	123	121.5	117.3
Scales, lateral series	154*	135.8	183.0
Scales above lateral line	30	–	–
Scales below lateral line	31	–	–
Interneural bones	13	–	–
Interhaemal bones	13	–	–
Thousands of standard length			
Body depth	264*	268	248
Head length	233	235	289
Head width	145	126	134
Least interorbit	70	75	74
Occiput to snout length	167	177	209
Maxilla length	93*	87	125
Caudal peduncle length	146	164	148
Caudal peduncle depth	113	104	101
Predorsal length	470	509	536
Preanal length	751	782	773
Prepectoral length	265	219	252
Prepelvic length	544	558	560
Dorsal, base length	141	139	140
Anal, base length	116	91	101
Pectoral length	163*	127	181
Pelvic length	138*	103	145
Eye diameter	43	45	71

* Values intermediate between means of parental species (cf. text)

† Data for *S. gairdneri* and *S. aguabonita* represent sample means ($\bar{X}$)

mechanisms among western trouts are more complete than presently believed. Busack (1977), for example, has recently presented evidence of two closely related inland cutthroat trout forms which coexist sympatrically without apparent gene exchange. The introgression frequently observed among western trouts in nature may indicate the well-known relationship between hybridization and habitat disruption (Anderson 1949).

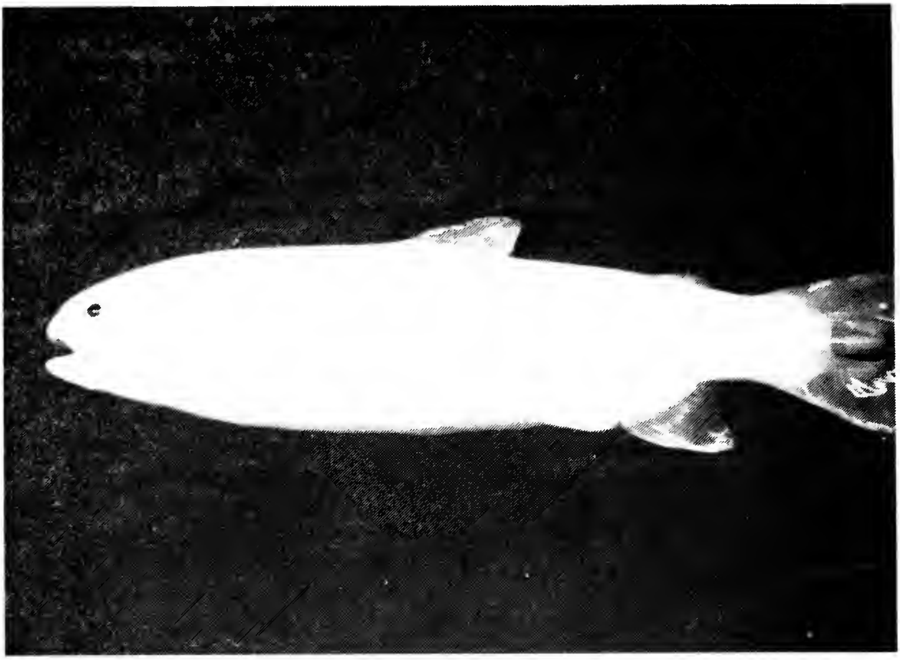

Figure 1. Lateral view of female *Salmo gairdneri* x *Salmo aguabonita* hybrid.

ACKNOWLEDGMENTS

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CALIFORNIA CONDOR SURVEY, 1978

A cooperative survey of California Condors, *Gymnogyps californianus,* was conducted 17 and 18 October 1978. Fifty observation stations were staffed by 110 observers from noon until condor flight activity ceased each day, usually about 5:00 p.m. All condor observations were recorded by time of day, direction of travel, age of birds (adult, immature, or undetermined), and distinguishing characteristics of individual birds (e.g., missing flight feathers). Total sightings were later evaluated to arrive at a probable minimum number of condors seen. Evaluation procedures remained the same as in previous surveys (see Mallette and Borneman, California Fish and Game 52(3):185–203, 1966). Records were also kept of other raptorial birds seen during the survey.

Most stations reported high broken cirrus clouds on 17 October but thick haze reduced visibility at most lowland stations. Temperatures at higher elevations were 15.5 C to 21.0 C; lower stations reported 21 C to 30 C. Winds were mostly from the southwest at less than 16 kmph. However, some higher elevations reported winds of 32 to 48 kmph.

On 18 October, winds shifted to the southeast and decreased somewhat. High clouds increased, and temperatures rose slightly at all stations.

Thirty-six total condor sightings were reported by 11 stations on 17 October; these represented a minimum of 12 individual condors (7 adults, 3 immatures, 2 unclassified). On 18 October, 15 stations reported 50 sightings; analysis indicated these represented at least 13 condors (7 adults, 4 immatures, 2 unclassified).

We do not know what proportion of the total population was accounted for on this survey, but other data collected in 1978 indicate that less than one-half of the condors were seen. Apparently some birds remained outside the survey area during the 2-day period. One encouraging note is that at least four immature (under 5 years of age) condors were seen, about as many as our nesting surveys have accounted for since 1974. This indicates excellent survival during the first few years of life and also suggests that our recent estimates of condor production may have been somewhat low.

Eleven other raptor species were observed (Table 1).

This report was prepared with the approval of the California Condor Recovery Team and is a contribution from Endangered Wildlife Program, E-W-3, California Department of Fish and Game, Nongame Wildlife Investigations.

Table 1. Raptors Observed During the Condor Survey, 17 and 18 October 1978

Species	*Numbers* *17 Oct.*	 *18 Oct.*
Turkey Vulture (*Cathartes aura*)	203	368
Golden Eagle (*Aquila chrysaetos*)	82	73
Sharp-shinned Hawk (*Accipiter striatus*)	20	18
Cooper's Hawk (*A. cooperii*)	26	16
Red-tailed Hawk (*Buteo jamaicensis*)	200	173
Swainson's Hawk (*B. swainsoni*)	2	38
Ferruginous Hawk (*B. regalis*)	6	3
American Kestrel (*Falco sparverius*)	53	51
Prairie Falcon (*F. mexicanus*)	5	2
Peregrine Falcon (*F. peregrinus*)	1	—
Marsh Hawk (*Circus cyaneus*)	4	6
Unidentified raptors	42	37
	644	785

—*Sanford R. Wilbur, U. S. Fish and Wildlife Service, 1190 E. Ojai Ave., Ojai, California 93023; Robert D. Mallette, California Department of Fish and Game, 1416 Ninth St., Sacramento, California 95814; and John C. Borneman, National Audubon Society, 2208 Sunridge Drive, Ventura, California 93003.* Accepted for publication February 1979.

THE RELATIONSHIP BETWEEN MEGALOPAE OF THE DUNGENESS CRAB, *CANCER MAGISTER,* AND THE HYDROID, *VELELLA* VELELLA, AND ITS INFLUENCE ON ABUNDANCE ESTIMATES OF *C. MAGISTER* MEGALOPAE

INTRODUCTION

Crab fishermen have long noted crab megalopae hanging onto floating objects and crab trap lines. Weymouth (1918) noted the presence of Dungeness crab, *Cancer magister,* megalopae on bells of several pelagic jellyfishes. The tendency of crab megalopae to attach to floating objects could make them unavailable to abundance surveys conducted with plankton nets sampling the open water column. In May 1975, I noted *C. magister* megalopae among the tentacles of the neustonic hydroid *Velella velella.* This hydroid occurred in high densities in the spring of 1975 while this year class of *C. magister* megalopae were making their inshore movement to crab nursery areas (Lough 1976). I investigated the degree of association between these two organisms to see whether a significant proportion of megalopae was removed from the water column.

MATERIALS AND METHODS

V. velella were sampled individually with dip net on 9 May 1975 from the Bodega Marine Laboratory's research boat. Stations were made along a transect from Bodega Bay, California, to 24 km offshore in a southwest direction. These stations were opportunistically determined due to the patchy distribution of *V. velella.* The individual hydroids were examined and associated crab megalopae were removed and counted. The gut contents of five megalopae obtained from

V. velella were examined for hydroid tissue. *V. velella* washed ashore were sampled and checked for the presence of crab megalopae.

A similar cruise was taken along the same transect in May 1976.

RESULTS

Samples obtained from stations between 0.8 km and 10.0 km from shore showed the presence of *C. magister* megalopae on 16–88% of the hydroids (Table 1). No megalopae were found on *V. velella* which were either beached or beyond 10.0 km.

Table 1. Sampling Data and Degree of Association of *Velella velella* and *Cancer magister* Megalopae

Station	*Distance from shore (km)*	*No. V. velella sampled*	*No. with crab larvae*	*Percent V. velella with crab larvae*
1	onshore	200	0	0.0
2	0.8	35	13	37.1
3	1.6	32	22	68.8
4	4.8	25	22	88.0
5	8.0	10	5	50.0
6	9.6	25	4	16.0
7	11.2–24.0	100	0	0.0

In 59 of the observed crustacean-hydrozoan associations, only 1 *C. magister* megalopa was present per individual hydroid. In six instances two were observed and, in one case, three were present on a single *V. velella*. In all cases, the megalopae were among the gonozooids underneath the hydroid float. Apparently no megalopae were harmed by the hydrozoan nematocysts; all were active and in good condition.

Other animals present on the hydrozoan were megalopae of another *Cancer* species, adult barnacles of a *Lepas* species, and barnacle cyprid larvae. Animals found inside the gonozooids were apparent food items and consisted of zoeae of the crab *Pugettia producta,* barnacle cyprids, and a cumacean.

The guts of the five megalopae were filled with tissue containing large numbers of unreleased *V. velella* nematocysts. One megalopa was preserved in the act of eating an entire gonozooid with its attached medusae buds.

During the dip net sampling in May 1975, few free swimming megalopae were observed. Personnel from the California Department of Fish and Game also observed *C. magister* megalopae on *V. velella* outside San Francisco Bay but found that megalopae were not present in plankton net samples taken when *V. velella* was present (Tasto et al. 1977).

No *V. velella* were found during the May 1976 cruise, nor were any observed in coastal waters or on the beach in the Bodega Bay area that year; however *C. magister* megalopae were abundant and could be seen swimming near the surface. I was able to observe these larvae as two distinct bands, one about 2-km wide from 1 km offshore and another approximately 5-km wide from 8 km offshore. A visual estimate of the average abundance indicated a density of roughly 1/m².

DISCUSSION

V. velella appears to provide several benefits to megalopae of *C. magister.* It provides (i) an abundant source of food, (ii) shelter from predatory pelagic fishes such as salmon which feed on them (Anon. 1949), and (iii) possible transportation into nearshore juvenile crab habitats. It is not known whether the presence of *V. velella* makes a significant contribution to year class abundance of Dungeness crabs. These hydroids only occur sporadically along the central California coast and their presence is unpredictable from year to year.

Cancer magister megalopae were not present in the surface waters or in net samples when *V. velella* was abundant, even though the crabs were abundant on the hydroids. Most surveys conducted to assess crab larval abundance rely on sampling with plankton nets (Sandifer 1973; Lough 1976; Tasto et al. 1977). Several million *V. velella* were present in the coastal waters near Bodega Bay in 1975 so the total number of crab megalopae associated with this hydroid could have been very high. The presence of *V. velella,* therefore, must be accounted for in any attempt to estimate *Cancer magister* megalopal abundance.

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WINTER FOOD HABITS OF FISHERS, *MARTES PENNANTI,* IN NORTHWESTERN CALIFORNIA

Very little is known about food habits of California fishers. Most information on this uncommon mustelid is summarized by Grinnell, Dixon, and Linsdale (1937). Recently a study of fisher abundance and distribution in California was completed by Schempf and White (1977). Currently, Humboldt State University, the U.S. Forest Service, and the California Department of Fish and Game are cooperating in a study of fishers in a study area in Trinity National Forest, Trinity County.

Chief foods of fishers in the Pacific coastal states are porcupines, squirrels, woodrats, mice, marmots, mountain beavers, quail, and grouse (Ingles 1965). A study conducted in Ontario, Canada, revealed that porcupines, muskrats, and snowshoe hares dominated the winter diet; a variety of other prey, such as squirrels, voles, mice, shrews, grouse, and jays was also consumed (Clem 1975).

Mice, squirrels, shrews, birds, fruit, and carrion were items most commonly found in fisher stomachs in a New Hampshire study (Kelly 1977).

From December 1977 through February 1978, eight fisher carcasses obtained from the Trinity County study area were made available for food habits study. Admittedly, the sample size is small, but fishers have been protected in California since 1946 and opportunities to investigate their food habits are extremely limited.

The vegetation of the study area consists of a mosaic of plant communities including Klamath montane forest with Douglas-fir, Klamath montane forest with yellow pine, Coast Range montane forest, Oregon oak forest; mixed evergreen forest with chinquapin, and mixed evergreen forest with rhododendron (Kuchler 1977). Elevations range between 610 and 1,070 m.

METHODS AND MATERIALS

Stomach contents were removed from fisher carcasses and preserved in 10% formalin. Identification was made by the Food Habits Section of the California Department of Fish and Game's Wildlife Investigations Laboratory at Sacramento.

All food material was washed and screened in a sieve measuring 14 squares per cm. Examination was done with a dissecting microscope and all identifiable items were grouped by categories. Hair was examined with a compound microscope. Plant and insect fragments and mammalian teeth and hair were identified by comparing them with known reference materials and by referring to appropriate texts.

Items were tallied by frequency of occurrence. Volumes were visually estimated in increments of 5%; volumes estimated to be less than 5% were recorded as a trace.

RESULTS AND DISCUSSION

The most significant food item, both by frequency of occurrence and by volume, was false truffle (subterranean fungi) (Table 1). False truffles have not been recorded in previous fisher studies; in our study, spores and tissue occurred in four samples. Three of these samples also contained hair from western harvest mice, deer mice, and black-tailed deer. False truffle is eaten by squirrels and other rodents in the southern United States (Miller and Halls 1969) and western gray squirrels in California have similar food habits (Stienecker and Browning 1970; Steinecker 1977). Whether fishers selectively feed on fungi or acquire them indirectly from their prey has not been resolved. However, one sample contained 90% false truffle by volume, compared with 10% western harvest mouse hair. None of the samples contained squirrel hair and fungi together. Selection of fungi by fishers is, therefore, a possibility.

The second most important food item by volume was bovine; however, this food item occurred in only one of eight samples (12.5%) and was probably carrion. Fishers were found to feed on carrion in the White Mountains of New Hampshire (Kelly 1977).

Deer hair was identified in two stomachs. The occurrence of deer in fisher digestive tracts has also been reported by other researchers. Frequency of occurrence of deer was 2.8% in fishers studied in Ontario, Canada (Clem 1975). In the New Hampshire study, deer hair found in fisher stomachs was attributed to carrion or trap-bait (Kelly 1977).

TABLE 1. Stomach Contents of Eight Fishers Collected During the 1977–78 Winter Season in Trinity County, California

Food item	*Frequency (%)*	*Volume (%)*
Plant		
False truffle (*Rhizopogon* sp), (spores and tissues)	50.0	28.0
Bark	50.0	7.5
Douglas-fir (*Pseudotsuga manziesii*), (leaves)	50.0	0.6
White fir (*Abies concolor*), (leaves)	12.5	0.6
Ceanothus (*Ceanothus* sp), (leaves)	12.5	T
Oak (*Quercus* sp), (leaves)	12.5	T
Forb (Dicotyledneae), (leaves)	12.5	T
Grass (Gramineae), (leaves and stems)	12.5	T
Moss (*Selaginella* sp), (leaves and stems)	12.5	T
Animal		
Fisher (*Martes pennanti*), (hair)	62.5*	0.6
Black-tailed deer (*Odocoileus hemionus*), (hair)	25.0	8.8
Deer mouse (*Peromyscus* sp), (hair)	25.0	3.1
Beetle (Coleoptera), (larvae, exoskeleton)	25.0	T
Bovine (*Bos taurus*), (hair, flesh)	12.5	11.3
Brush rabbit (*Sylvilagus bachmani*)	12.5	10.0
Broad-handed mole (*Scapanus latimanus*), (hair)	12.5	8.1
Western gray squirrel (*Sciurus griseus*), (hair and teeth)	12.5	7.5
Western harvest mouse (*Reithrodontomys megalotus*), (hair)	12.5	1.3
Mammal claws	12.5	0.7
Arthropoda (fragments)	12.5	T
Miscellaneous		
Grit	62.5	8.1
Bone fragments	12.5	2.5
Flesh, unidentified	12.5	1.3
		100.0

T = Trace
* Usually ingested while grooming

No porcupine remains were found in our specimens, but evidence of porcupine-fisher interaction in the study area has been reported; 1 of 10 live-captured fishers and 2 necropsied fishers had quills embedded in their hides (C. Mullis, student, Humboldt State University, pers. commun.). Similarly, porcupine was not found in 40 fisher stomachs examined in New Hampshire, but 15% of 89 fishers contained quills in their pelts (Kelly 1977).

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Tim Burton, California Department of Fish and Game Wildlife Biologist, and Curt Mullis, a student at Humboldt State University, provided the specimens for examination. Oscar Brunetti, California Department of Fish and Game, Wildlife Pathologist, confirmed the identification of false truffle.

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AN ANTI-ROLL BEACH SEINE

The netting of a beach seine will often roll up into a tight "rope" when used where submerged, attached plants, such as eelgrass, *Zostera marina*, are present. When this occurs, fishes can no longer be caught in the seine.

My observations indicate that net rolling is caused by attached plant leaves being "caught" by the netting of the seine. The attached leaves "escape" the seine by dragging the netting down, in front of, below, and behind the foot rope as the seine passes through and over attached vegetation. This causes the netting to become rolled up into a tight "rope".

An anti-roll beach seine was constructed for use in eelgrass areas. It was made of a rectangular piece of 10-mm stretched mesh cotton netting suspended between two wooden poles (Figure 1). The head rope was buoyed by two 120-mm long and 80-mm wide foam floats. The main foot rope was weighted to 1.1 kg with 7-mm wide pencil lead that was bent and coiled around the main foot rope. A secondary foot rope was attached to the netting in several places as well as to the ends (Figure 1). It was weighted to 1.25 kg in the manner described for the main foot rope. Four chains were tied with nylon twine to both foot ropes (Figure 1). Each chain weighed 0.3 kg and was constructed of nineteen 42-mm long and 4.8-mm thick links.

This seine did not roll because the forward and downward drag of the eelgrass leaves against the netting was counteracted by a backward drag of the secondary foot rope and chains against the middle of the seine. This anti-roll beach seine can be used to capture fishes wherever submerged vegetation causes other beach seines to roll.

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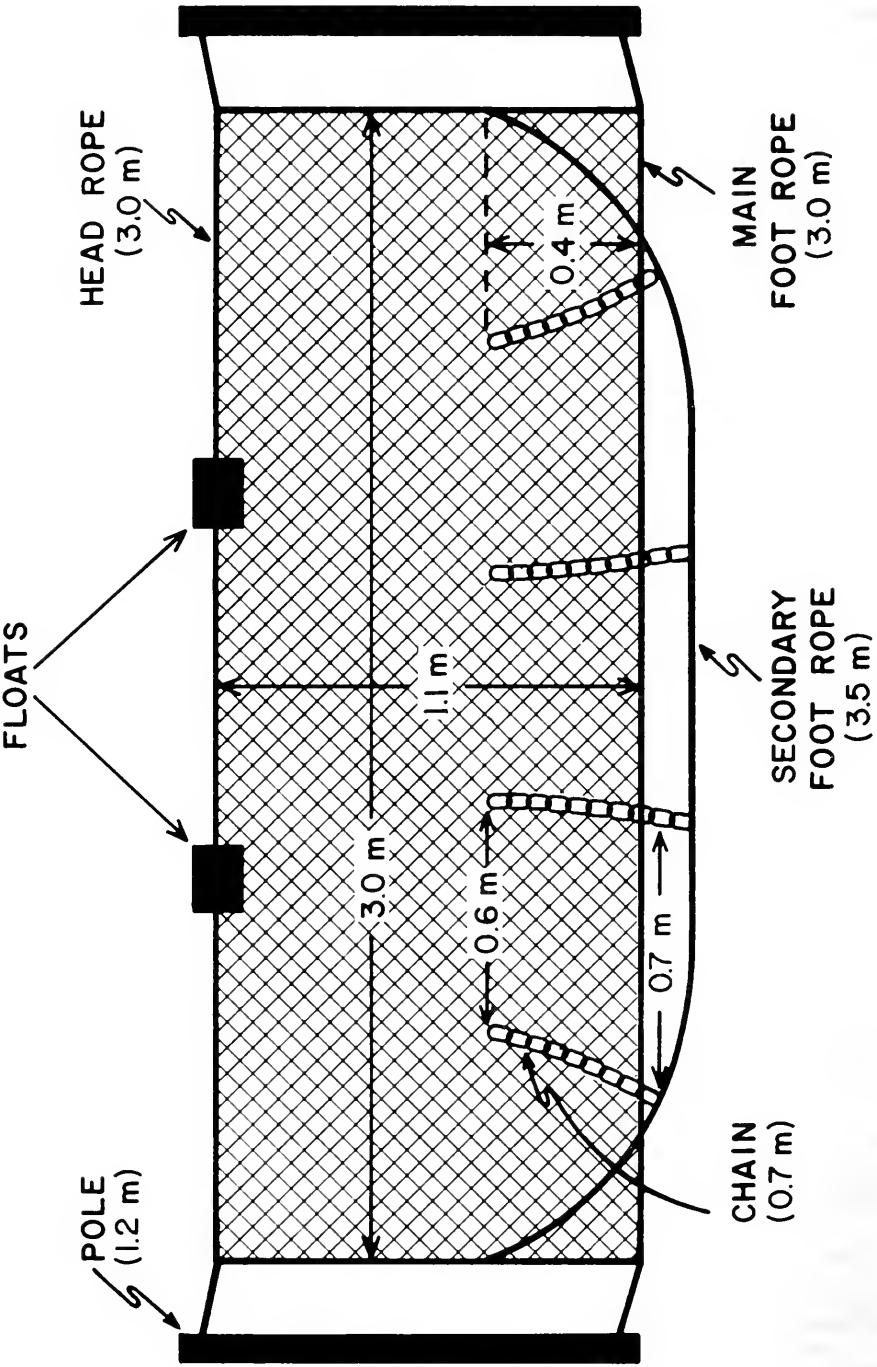

Figure 1. Back view of the anti-roll beach seine.

TERM FETUSES FROM A LARGE COMMON THRESHER SHARK, *ALOPIAS VULPINUS*

Little is known of the life history of the common thresher shark. It has been determined that this ovoviviparous species attains maturity at a length of approximately 4.2 m, and, on a worldwide basis, probably reaches a maximum length of some 6 m (Bigelow and Schroeder 1948). Most threshers taken in California waters are less than 2.4 m in length (Roedel and Ripley 1950; Fitch 1974), although larger specimens are often captured off southern California, particularly by anchovy purse seiners and barracuda gill-netters during summer months (J. Fitch and D. Schultze, Calif. Dept. Fish and Game, pers. commun.). Unfortunately, few of these large threshers have been closely examined before being cleaned. This note describes term fetuses taken from one such specimen.

On 3 June 1977, Michael McCorkle of the commercial fishing vessel PIE FACE landed a large female thresher that had become entangled in his gill nets the previous night. The nets had been set in 13 fm of water approximately 2 nautical miles off Solimar Beach near Ventura, California. The length of the fish was estimated at greater than 4.6 m and its weight was measured at 295 kg. When the thresher was cleaned, four large fetuses were removed, two of which were badly mutilated in the process. The intact specimens were donated to the University of California at Santa Barbara, and subsequently deposited at the Museum of Ichthyology in the Department of Biological Sciences.

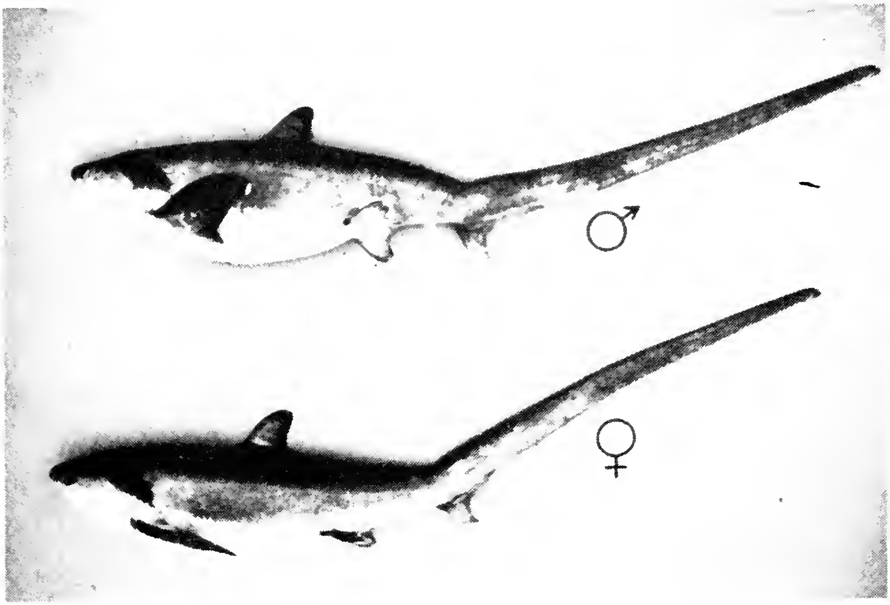

Figure 1. Male and female term fetuses of the common thresher shark. *Photograph by G. M. Wellington, June 1977.*

The two fetuses had been very near birth, as evidenced by their lack of umbilical scars and their large size (Figure 1). The male was 1417 mm in total length and weighed 8.8 kg fresh, while the female was 1386 mm long and weighed 7.7 kg. These specimens approach the maximum fetal size of 1550 mm reported by Bigelow and Schroeder (1948). Moreover, free-living threshers considerably smaller than the fetuses have been taken off California (Herald and Ripley 1951), as well as off the eastern United States (Bigelow and Schroeder 1948).

In 1954, another large thresher carrying four term fetuses was captured off Newport Beach (Joseph 1954). Although it was larger than the one reported here (approximately 5.4 m) the fetuses were somewhat smaller and still exhibited umbilical scars.

As a final note, the litter size of the common thresher shark is invariably reported as ranging from two to four pups (Bigelow and Schroeder 1948; Roedel and Ripley 1950). However, McCorkle (pers. commun.) once captured a thresher that carried six fetuses.

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