CALIFORNIA FISH AND GAME

"CONSERVATION OF WILDLIFE THROUGH EDUCATION"

VOLUME 74 OCTOBER 1988 NUMBER 4

California Fish and Game is a journal devoted to the conservation and understanding of fish and wildlife. If its contents are reproduced elsewhere, the authors and the California Department of Fish and Game would appreciate being acknowledged.

Subscriptions may be obtained at the rate of $10 per year by placing an order with the California Department of Fish and Game, 2201 Garden Road, Monterey, CA 93940. Money orders and checks should be made out to *California Fish and Game.* Inquiries regarding paid subscriptions should be directed to the Editor.

Complimentary subscriptions are granted on an exchange basis.

Please direct correspondence to:

Robert N. Lea, Ph.D., Editor-in-Chief
California Fish and Game
2201 Garden Road
Monterey, CA 93940

CALIFORNIA FISH AND GAME

VOLUME 74 OCTOBER 1988 NUMBER 4

Published Quarterly by
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF FISH AND GAME
—LDA—

STATE OF CALIFORNIA

GEORGE DEUKMEJIAN, *Governor*

THE RESOURCES AGENCY

GORDON VAN VLECK, *Secretary for Resources*

FISH AND GAME COMMISSION

DEPARTMENT OF FISH AND GAME

PETE BONTADELLI, *Director*

1416 9th Street

Sacramento 95814

CALIFORNIA FISH AND GAME

Editorial Staff

CONTENTS

NOTES

Calif. Fish and Game 74(4): 196–202 1988

PRESENT DISTRIBUTION OF RINGTAILS IN CALIFORNIA[1]

SUSAN ORLOFF
BioSystems Analysis Inc.
GGEC/GGNRA
Fort Cronkhite, Building 1065
Sausalito, CA 94965

The current distribution of ringtails, *Bassariscus astutus,* in California was determined from sighting records, museum specimens, and recent literature, which yielded 446 occurrence reports, representing 595 ringtails. This distribution extends throughout most of California with the exception of the extreme northeast corner of the state and southern portions of the San Joaquin Valley. The known range of ringtails, as described by Grinnell et al. (1937) has been extended to include the Mojave and Colorado Deserts, Sacramento Valley, northern portions of the San Joaquin Valley, northern Mono County, the high Sierra Nevada south of Lake Tahoe, and northeastern portions of the state. Occurrence reports suggest that ringtails are most abundant along riparian areas in northern California and Sierra Nevada foothills.

INTRODUCTION

The distribution of ringtails, *Bassariscus astutus,* in California was described by Grinnell, Dixon, and Linsdale in 1937. This widely accepted account indicates that ringtails were absent from certain sizable areas of the state, most notably the Central Valley (Sacramento and San Joaquin valleys), Mojave and Colorado deserts, and the northeastern portion of the state.

Since that publication, reports of ringtails occurring in portions of the Sacramento Valley have been documented by Naylor and Wilson (1956), Michny et al. (1975), and Stone (1976). A recent paper documents the presence of ringtails in the northern San Joaquin Valley and high densities of ringtails associated with riparian habitat of the Sacramento Valley (Belluomini and Trapp 1984).

Major mammalian reference works and distributional reviews (Ingles 1965; Schempf and White 1974, 1977; Hall 1981) subsequent to Grinnell et al. (1937) have acknowledged the presence of ringtails in portions of the Sacramento Valley but not in the San Joaquin Valley. Principal authorities agreed with Grinnell et al. (1937) that ringtails were absent from most true desert areas and the northeastern portion of the state (Hall and Kelson 1959, Ingles 1965, Hall 1981), although Hall (1981) documented a limited distribution of ringtails adjacent to the Colorado River in the Colorado Desert.

In 1967, the California Legislature listed the ringtail as a fully protected mammal; prior to this it was a harvested furbearer. Information on the status of ringtails in California is scarce. The primary purpose of this study was to document and describe further the distribution of ringtails in California.

METHODS

Current distribution and abundance data on ringtails were gathered in two ways: (i) sighting reports were solicited from appropriate state and federal

---

[1] Accepted for publication July 1988.

agencies, knowledgeable field biologists, and licensed trappers; (ii) telephone interviews were conducted with personnel from natural history museums, California universities and colleges, and state and federal agencies to obtain sighting reports and information from museum collections.

Data collected were added to ringtail sightings previously reported by Schempf and White (1974, 1977) and Swick (1974). All ringtail occurrence reports from 1960 to 1980 were tabulated and mapped. (Occurrence records are stored at the California Department of Fish and Game—Nongame Wildlife Office, Sacramento, California). This current distribution pattern was then compared to historical records (Grinnell et al. 1937, Hall and Kelson 1959, Ingles 1965).

RESULTS

Distribution

A total of 446 reported occurrences, representing 595 ringtails, was obtained during this study. Sixteen percent of these occurrence reports represented actual specimens (i.e., museum specimens, road kills, or trapped individuals). The majority of the occurrences were found within the range limits previously designated by Grinnell et al. (1937) (Figure 1). One hundred and eighteen occurrences of ringtails were reported outside of this range. The most notable extensions in known range occurred in the Mojave Desert, Central Valley, and the northeast portion of the state.

Ringtails were reported in 49 of 58 counties; Grinnell et al. (1937) found that ringtails occurred in only 37 counties (Table 1). Neither Grinnell et al. nor this study was able to contribute occurrence records for eight counties. Of these counties, data from annual California Fish and Game trapping records indicate that ringtails have never been reported taken from Alpine, Orange, or San Francisco counties; ringtails have not been reported taken since the 1940's in Kings, Marin, and Santa Clara counties. In the remaining two counties, Merced and Stanislaus, trapping records indicate ringtails were taken after 1960 (Table 1).

Elevational Distribution

Present data on elevational distribution of ringtails compare closely with past reports; ringtails occur from sea level (Grinnell et al. 1937) to 2680 m (Schempf and White 1977).

Subspecies

Figure 2 delineates the probable expanded distribution of five subspecies of ringtail in California given the current data. Grinnell et al. (1937) described three subspecies of ringtails in California. The California ringtail, *B. a. raptor,* was described as occurring along the western slope of the Sierra Nevada and the Pacific drainage slope from the Oregon border to Ventura County where this race intergrades with the San Diego race, *B. a. octavus.*

Current data indicate extensions of this range in several areas including: the northern portions of the San Joaquin Valley; Sacramento Valley; western slope of the Sierra Nevada in El Dorado, Fresno, and Tulare counties; and the northeastern portion of the state.

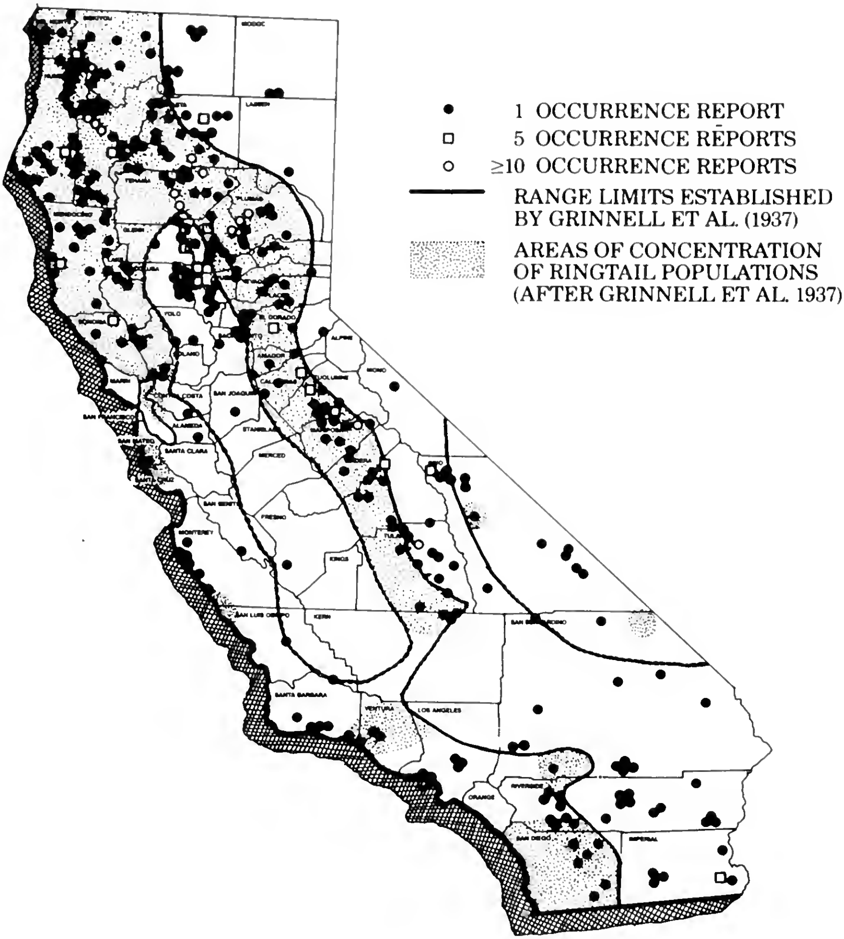

FIGURE 1. Distribution of ringtail occurrence reports in California (1960–1980) compared to historical range.

According to Grinnell et al. (1937), the range of *B. a. octavus* extended primarily along the Pacific slope of southwestern California from Ventura County to the southern border of the state. Current data suggest the possible expansion of this range into Imperial County, eastern Riverside County, and southern and western San Bernardino County.

The Nevada ringtail, *B. a. nevadensis,* was thought to occur east of the Owens River, primarily in Inyo County. Data obtained during this study suggest an extension of this previously described range into Owens Valley near Bishop and Coso junction, and into northern Mono County. It appears that the Sierra Crest is still the western barrier for this race. Ringtails reported in central and eastern San Bernardino County were thought to be the Nevada ringtail also; one of these occurrences was a museum specimen identified as *B. a. nevadensis* (D.Bontrager, Cal. State Long Beach, pers. comm.).

TABLE 1. County Distribution and Licensed Fur Trapper Take of Ringtails in California.

County	*Number of Occurrence Reports Grinnell et al. (1937)*	*Number of Occurrence Reports This Study*	*Average Annual Take per County*[1]	*Range of Take*	*Number Seasons Ringtail Taken*	*Record of Ringtail Take After 1960*
Alameda	1	1	0.10	3	1	
Alpine	0	0				
Amador	5	2	4.34	1–45	7	
Butte	11	41	59.17	4–219	29	X
Calaveras	5	7	10.55	1–92	14	X
Colusa	4	7	3.03	1–9	13	X
Contra Costa	0	1	0.31	1–5	3	
Del Norte	1	5	7.28	1–48	16	X
El Dorado	4	7	11.66	1–66	15	X
Fresno	5	17	7.31	1–93	20	X
Glenn	1	2	5.66	1–20	25	X
Humboldt	27	23	30.03	1–160	28	X
Imperial	0	10	0.66	1–11	7	
Inyo	1	17	0.97	1–8	9	
Kern	5	3	0.83	1–9	8	
Kings	0	0	0.10	3	1	
Lake	5	5	2.90	1–23	16	X
Lassen	1	1	0.75	1–17	6	
Los Angeles	0	5	0.83	1–5	9	
Madera	4	4	7.48	1–44	11	
Marin	0	0	0.03	1	1	
Mariposa	3	17	19.83	3–101	18	X
Mendocino	16	17	11.24	1–47	25	X
Merced	0	0	1.28	1.32	4	X
Modoc	0	2	0.28	1–6	3	X
Mono	0	1	0.24	1–2	5	
Monterey	0	6	0.41	1–7	3	
Napa	2	6	0.21	1–2	4	
Nevada	4	3	11.00	1–53	25	X
Orange	0	0	–	–	–	
Placer	10	7	15.62	1–75	21	X
Plumas	1	25	6.97	1–28	22	X
Riverside	0	19	1.00	1–11	6	
Sacramento	1	4	0.38	1–6	5	X
San Benito	0	1	–	–	–	
San Bernardino	4	13	1.10	1–7	10	X
San Diego	3	6	0.62	2–12	3	
San Francisco	0	0	–	–	–	
San Joaquin	0	2	0.86	1–22	3	X
San Luis Obispo	2	2	0.03	1	1	
San Mateo	0	1	–	–	–	
Santa Barbara	0	6	0.45	1–10	3	
Santa Clara	0	0	0.03	1	1	
Santa Cruz	1	0	–	–	–	
Shasta	10	36	57.03	1–234	28	X
Sierra	1	2	1.79	1–13	14	X
Siskiyou	6	33	12.97	1–60	25	X
Solano	1	2	0.07	2	1	
Sonoma	10	8	0.93	1–9	9	
Stanislaus	0	0	2.62	1–8	12	X
Sutter	0	10	1.14	1–6	15	X
Tehama	11	109	11.97	1–48	25	X
Trinity	8	55	37.59	3–108	29	X
Tulare	6	20	14.17	1–103	15	X
Tuolumne	4	15	19.52	1–126	13	
Ventura	2	2	0.66	1–7	7	
Yolo	0	1	0.66	1–13	5	
Yuba	4	6	6.14	1–48	22	X
	190	595				

---

[1] Reported take divided by 29 seasons (1938–1966) of trapping records.

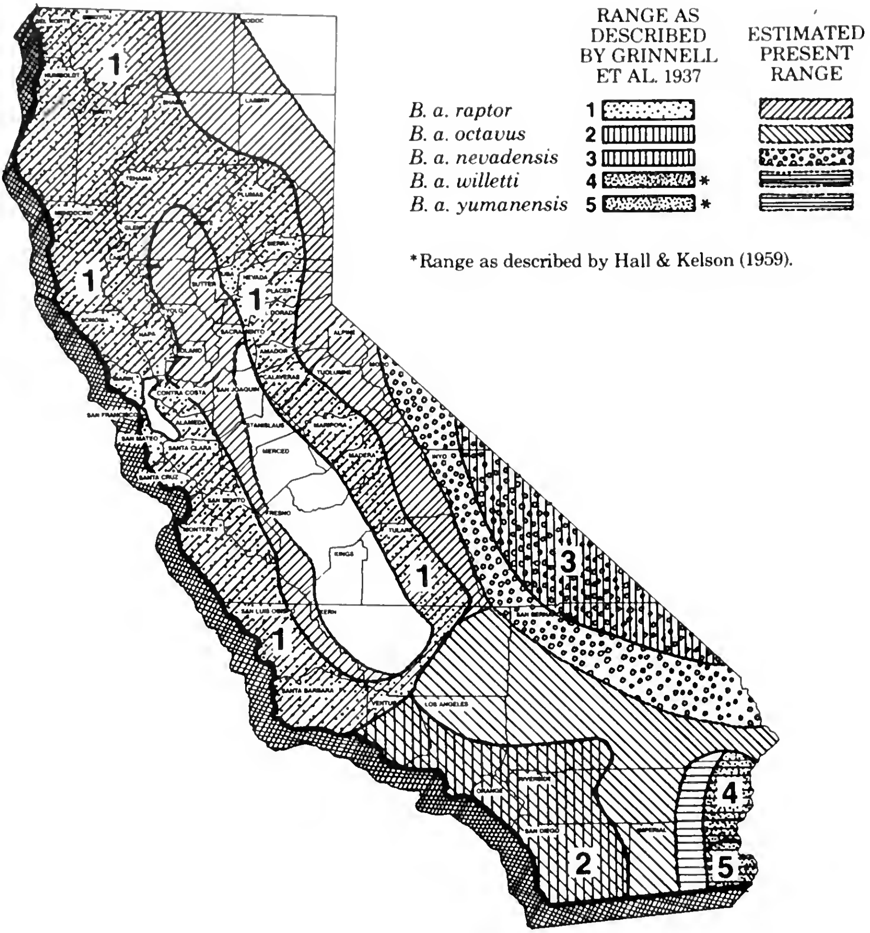

FIGURE 2. Comparison of present and historical range of the subspecies of ringtail in California.

Ringtails occurring in the Colorado Desert could be classified as one of two subspecies described in Hall and Kelson (1959), *B. a. willetti* or *B. a. yumanensis.*

Relative Abundance

Ringtails appear to prefer riparian areas as indicated by numerous sightings along many of the major California rivers, including the Eel, Feather, Klamath, Kaweah, Mad, Merced, Sacramento, Salmon, and Trinity rivers.

Current data suggest that northern California still contains the highest density of ringtails, as it did during Grinnell's era (Grinnell et al. 1937). Current ringtail reports are most abundant from Tehama County with fewer but notable numbers found in Butte, Humboldt, Plumas, Shasta, Siskiyou, and Trinity counties. Tehama County had the only two occurrence reports of more than 10 ringtails at a single location. These two occurrences, reported approximately 1 year apart, were located in Manton and along the Sacramento River, where 40 and 50 ringtails were trapped, respectively (Swick 1974).

An abundance of ringtail sightings was reported in the northern Sacramento Valley near Butte Creek and Sutter Buttes. This population, which is outside of the range described by Grinnell et al. (1937), has been previously documented in the literature (Naylor and Wilson 1956, Schempf and White 1977, Belluomini and Trapp 1984). Belluomini and Trapp (1984) documented the highest reported ringtail densities in the literature within the Sacramento Valley, along the lower Feather River and portions of the Sacramento River.

The fewest numbers of ringtail occurrence reports were found in the Mojave and Colorado deserts, the eastern slopes of the Sierra Nevada, the San Joaquin Valley, and northeastern California.

The number of occurrence reports of ringtails obtained by Grinnell et al. (1937) and by this study were compared for each county (Table 1). Grinnell et al. (1937) included ringtail occurrences reported by trappers during a 3-year period (1919–1922), and those from examined specimens. Due to the differing levels of effort expended in both studies and demographic changes that have occurred since Grinnell's time, it is very difficult to determine changes in abundance. However, there was a marked increase (10-fold or greater) of occurrence reports over historical data in four counties: Inyo, Plumas, Riverside, and Tehama. Seven counties showed a decrease in occurrence reports: Amador, Humboldt, Kern, Nevada, Placer, Santa Cruz, and Sonoma.

DISCUSSION

The distribution of ringtails in California is considerably more extensive than previously believed. Early authorities agreed that ringtails were absent from most of the Central Valley and Mojave Desert (Grinnell et al. 1937, Hall and Kelson 1959, Ingles 1965). Current data prove that ringtails do exist in these seemingly unsuitable areas.

Without complete and reliable historical information on ringtail distribution, it is very difficult to determine whether any true extensions of the ringtail's range have occurred. Historical trapping records (California Department of Fish and Game, unpublished data) and occurrence records (museum specimens) indicate that during Grinnell's era ringtails did occur in all of the areas now determined as range extensions. Therefore, these extensions in known range are probably not true expansions in range of the ringtail; rather, they reflect a greater utilization of available information.

Although ringtails have never been reported to occur in Alpine, Orange, and San Francisco counties, there is suitable habitat in Alpine and Orange counties that may support small populations of ringtails. Marin and Santa Clara counties have no record of ringtails found since the 1940's, but current sightings have been reported near their boundaries.

Ringtails typically have been associated with chaparral habitat and rocky terrain (Seton 1929, Grinnell et al. 1937, Hall 1981). Recent evidence indicates that ringtails also have a strong affinity for riparian areas in the northern Central Valley (Belluomini and Trapp 1984). Current data suggest that while ringtails appear to show a preference for riparian areas throughout the state, they are apparently well adaptable to a wide range of habitats; the occurrence of ringtails has been documented in almost every habitat type in California. Apparently, the only types of habitat in which ringtails have not been found are the Northern Juniper Woodlands (as defined by Munz and Keck 1959) and the highly developed agricultural portions of the San Joaquin Valley.

ACKNOWLEDGMENTS

I thank L. Belluomini and G. Trapp for their efforts in conceiving and initiating this project. For his assistance in preparing this manuscript, I give special thanks to G. Gould. I also extend my appreciation to the personnel of the following government agencies: National Forest Service, Bureau of Land Management, National Park Service, and California Department of Fish and Game. The museum personnel from the University of California campuses, State Universities, and regional natural history museums also provided valuable information. Lastly, I am grateful to V. Gizinski and L. Baker for critically reviewing the manuscript. I was employed by the California Department of Fish and Game, Nongame Wildlife Division, Sacramento, during data collection and analysis.

LITERATURE CITED

Belluomini, L., and G. Trapp. 1984. Ringtail distribution and abundance in the Central Valley of California. Pages 906–914 *in:* R. Warner and M. Hendrix, eds. Calif. Riparian Systems Conference: Ecology, Conservation and Productive Management. Univ. of Calif. Press, Berkeley. 1035 p.

Grinnell, J., J. S. Dixon, and J. M. Linsdale. 1937. Fur-bearing mammals of California. Univ. California Press, Berkeley, 1:xii + 1–376.

Hall, E. R. 1981. The mammals of North America. Second ed. John Wiley & Sons, New York, 2:601–1181.

Hall, E. R., and K. R. Kelson. 1959. The mammals of North America. The Ronald Press Co., New York, 2:547–1083 + 79.

Ingles, L. G. 1965. Mammals of the Pacific states. Stanford Univ. Press, Stanford, California. 506 p.

Michny, F. J., D. Boos, and F. Wernette. 1975. Riparian habitats and avian densities along the Sacramento River. California Dept. of Fish and Game, Sacramento, Calif., Adm. Rep. No. 75-1, 42 p.

Munz, P. A., and D. D. Keck. 1959. A California flora. Univ. of California Press, Berkeley. 1681 p.

Naylor, A. E., and G. W. Wilson. 1956. Unusual occurrence of the ring-tailed cat. Calif. Fish Game, 42(3):231–232.

Schempf, P. F., and M. White. 1974. A survey of the status of seven species of carnivores on National Park Service lands in California. Report to U.S. Natl. Park Serv., 129 p.

________. 1977. Status of six furbearer populations in the mountains of northern California. U.S. Dept. of Agric. Publ., Forest Service, California Region, 51 p.

Seton, E. T. 1929. Lives of game animals. Doubleday, Doran and Co., Garden City, New York, 2:xvii + 1–746.

Stone, T. B. 1976. Observations on furbearers within the riparian habitat of the upper Sacramento River. Calif. Dept. of Fish and Game, Memorandum Report, 12 p.

Swick, C. D. 1974. California furbearer survey trapper interview. California Dept. of Fish and Game, Special Wildlife Invest., 10 p.

Calif. Fish and Game 74(4): 203–207 1988

INFLUENCE OF MATURITY ON STRAYING RATES OF SUMMER STEELHEAD INTO THE ROGUE RIVER, OREGON[1]

THOMAS D. SATTERTHWAITE
Oregon Department of Fish and Wildlife
850 SW 15th Street
Corvallis, Oregon 97333

We captured large numbers of stray summer steelhead, *Salmo gairdneri,* in the Rogue River, Oregon, from 1977 through 1982. More than 95% of the marked strays originated from Iron Gate and Trinity River hatcheries in the Klamath River basin of northern California. Immature steelhead (half-pounders) strayed at significantly higher rates than mature adults. Returning to the natal stream is probably of less adaptive value for half-pounders as compared with maturing adults.

INTRODUCTION

The tendency of Pacific salmon, *Oncorhynchus* spp., and steelhead, *Salmo gairdneri,* to return to natal streams for spawning is widely known. Precise homing may increase survival rates of progeny because distinct stocks of anadromous salmonids appear genetically adapted to the particular characteristics of their environment (Helle 1981). However, some adults stray to spawn in non-natal streams. Straying is most pronounced for transplanted stocks (Ricker 1972), but has also been noted in native stocks (Quinn and Fresh 1984).

Everest (1973) observed a substantial interchange of summer steelhead between the Rogue River in southern Oregon and streams in northern California. These strays were primarily small steelhead 28 to 38 cm in length, known locally as "half-pounders". Half-pounders have a unique life history among steelhead and are limited in distribution to the Eel and Klamath river basins of northern California and the Rogue River in southern Oregon (Figure 1). Other streams in close proximity to these rivers contain steelhead that return as adults only during the winter. Half-pounders return to freshwater during the late summer after spending about 4 months in the ocean (Kesner and Barnhart 1972). Most do not mature, but migrate to the ocean during spring of the succeeding year. Maturing adults return to the Rogue River mostly as summer steelhead, but some also return as winter steelhead (Cramer and McPherson 1982).

In this note, I assess the influence of maturity stage on the straying rate of summer steelhead into the Rogue River and discuss the ecological implications of the differential straying rates of half-pounders and adults.

METHODS

From 1977 through 1982, crews collected summer steelhead at Huntley Park (River Kilometer 13) with a 90 x 3.2-m beach seine. Two wing panels 23 m in

---

[1] Accepted for publication July 1988.

length, with 7.6 cm square mesh, bracketed a center panel 44 m in length, with 3.5 cm square mesh. We seined 3 days weekly (Monday, Wednesday, and Friday) with a three or four person crew from 10 July through 21 October. Seining began 30 min after sunrise and continued until we completed 15 sets (16 in 1978).

Personnel segregated steelhead by length and hatchery marks. Based on findings by Everest (1973), we classified steelhead smaller than 40.5 cm as half-pounders and larger steelhead as adults. Steelhead were examined for fin clips, brands, or other identifying marks and were measured to the nearest 0.5 cm (fork length) prior to release.

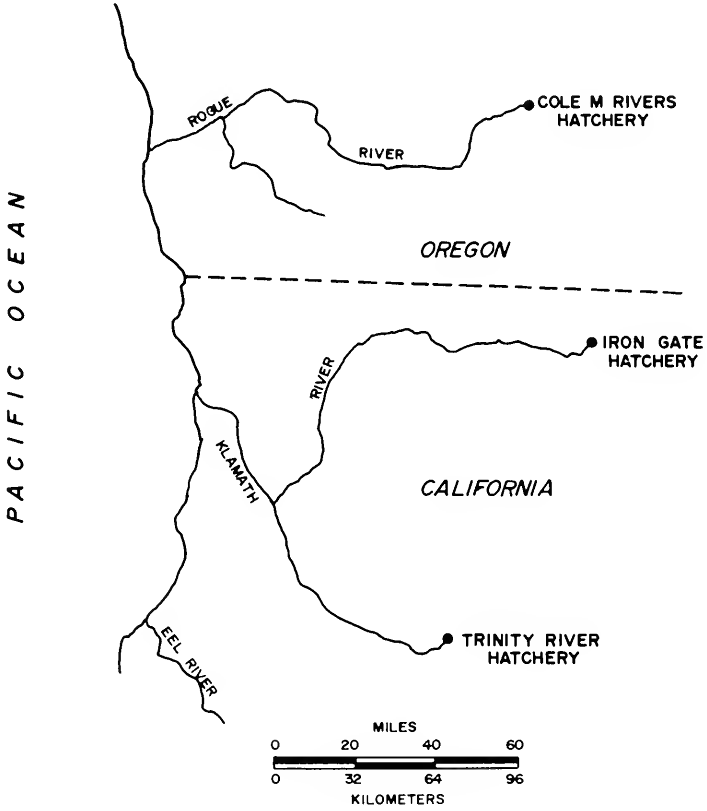

FIGURE 1. River basins with runs of half-pounders in southern Oregon and northern California.

RESULTS

We observed fin clips and cold brands on 2,876 of the 23,058 summer steelhead seined at Huntley Park from 1977 through 1982. Most (83%) of these marked fish originated from juveniles released into the Rogue River from Cole M. Rivers Hatchery. However, 17% of the marked steelhead were released from hatcheries outside of the Rogue River basin. More than 95% of these strays originated from Iron Gate and Trinity River hatcheries in the Klamath River basin of northern California (Table 1).

TABLE 1. Number of Marked Summer Steelhead Released From Various Hatcheries and Recaptured By Seining At Huntley Park, 1977–1982.

				Number seined at Huntley Park	
Hatchery	*Release year*	*Fin clip*	*Number released*	*Half-pounders*	*Adults* [a]
Iron Gate (Klamath River)	1977	D-Ad, ADLP, ADRP	483,742	25	1
	1978	LVRV	200,000	24	2
	1978	D-Ad, LV, RV	345,491	6	3
	1980	Ad	170,117	94	4
	1981	LV	235,730	18	2
Trinity River	1977	LVRP, RVLP, AdLVRP, ADRVLP	370,295	82	4
	1978	ADLVRV	152,876	15	1
	1979	LP, RP, AdLV, AdRV	437,575	59	8
	1980	RVLP, LVRP, AdLP, AdRP	314,689	66	4
	1981	AdRVLP, LVRV, AdLVRP AdRV, AdLV, RV	226,518	49	4
Other	1977–1981	numerous [b]	unknown	21	3
Cole M. Rivers (Rogue River)	1977–1981	numerous	506,549	2,131	262

---

[a] Captured 1 and 2 years after release.

[b] Includes marks of unknown origin.

From 1977 through 1981, strays originating from hatcheries in the Klamath basin composed an average of 2.8% of the annual returns of half-pounders to the Rogue River. Their importance in the runs varied considerably, ranging from a low of 1.2% in 1981 to a high of 5.8% in 1979. In contrast, marked adults from Klamath basin hatcheries composed an average of 0.8% of the annual returns of adults in 1978 through 1982 and ranged from 0.5% in 1979 to 1.4% in 1980.

Comparisons of the relative abundance of strays within returns of marked half-pounders and subsequent adult returns indicated that half-pounders strayed at higher rates than adults (Table 2). For example, Klamath strays composed 20% of the marked half-pounders seined in 1977, but only 7% of the marked adults seined in 1978. This degree of change implies that half-pounders strayed at a 183% higher rate than cohorts that strayed as adults. The decrease in straying as steelhead matured was significant ($p < 0.05$) in the 1977/1978, 1979/1980, and 1980/1981 returns (Table 2). Changes in run composition within the five half-pounder and subsequent adult returns suggested that straying rates of half-pounders were 87% higher (95% CI = ±71%) than the straying rates of adults.

TABLE 2. Percentage of Marked Klamath Steelhead in the Seine Catches of Marked Steelhead at Huntley Park on the Rogue River, 1977–1982.

Half-pounders		*Adults*		
Return year	*Percentage Klamath ± 95% CI* [a]	*Return year*	*Percentage Klamath ± 95% CI* [a]	*P for difference*
1977	20.1 ± 3.6	1978	7.1 ± 6.8	0.004
1978	5.8 ± 2.0	1979	3.4 ± 4.4	0.173
1979	72.3 ± 10.4	1980	40.0 ± 22.6	0.002
1980	18.7 ± 2.6	1981	11.2 ± 6.8	0.048
1981	17.9 ± 3.8	1982	11.9 ± 11.4	0.164

---

[a] 95% CI = $\pm t_{.05,\, n\text{-}1} * (\sqrt{pq/n\text{-}1} + \frac{1}{2}n)$

DISCUSSION

Most biologists recognize the proclivity of anadromous salmonids to return to natal streams with the onset of maturity. However, we found that large numbers of steelhead from the Klamath River basin strayed 100 km north to enter the Rogue River. Marked steelhead released from hatcheries in the Klamath basin composed 3% of the half-pounders seined in the Rogue from 1977 through 1981. During the same years, their cohorts accounted for 10% of the half-pounders seined from the Klamath River (Calif. Dept. Fish and Game, Arcata, unpubl. data). Assuming the runs in both rivers were of similar magnitude, then about 23% (3% ÷ 3%+10%) of the half-pounders originating from Klamath basin hatcheries strayed into the Rogue River.

Wild half-pounders also stray between rivers; possibly to the same degree as hatchery half-pounders. Everest (1973) tagged wild half-pounders in the Rogue River that surveyors found spawning 1 year later in the Klamath River basin. Our tagging studies in 1977 and 1978 confirmed his findings that wild-summer steelhead stray between river basins (Oregon Dept. of Fish and Wildl., unpubl. data).

The entry of immature individuals from saltwater into non-natal streams is not a unique characteristic among anadromous salmonids. Jones (1977) found maturing adults composed less than 50% of the anadromous cutthroat trout, *Salmo clarki,* entering an Alaskan stream. He tagged immature cutthroat as they returned to the ocean. Later, some of these individuals were recaptured as mature adults in other streams 1 to 44 km from the tagging site. Johnston (1981) outlined similar migrational patterns of anadromous cutthroat in some tributaries of Puget Sound and the Columbia River. He felt that the movement of immature cutthroat into non-natal streams represented a complex behavior pattern rather than random straying. The following evidence appears to support his contention.

Many juvenile salmonids migrate in fairly precise patterns. For example, young fry of sockeye salmon, *Oncorhynchus nerka,* will migrate upstream against a current to reach appropriate rearing areas (Raleigh 1967). Experiments by Brannon (1972) showed that the genetic history of parental sockeye influenced the migratory behavior of the progeny. Juveniles of other species of salmonids also make extensive migrations (Hoar 1976). Many biologists believe that such migratory patterns developed so that juveniles could rear in areas where improved environmental conditions increase survival to maturity.

This theory makes the migration of half-pounders into freshwater a paradox because river conditions at the time of entry appear marginal for salmonids due to low flows and high water temperatures. Changes in body condition and growth rate indicate that development slows after entry into freshwater. Kesner and Barnhart (1972) found the body condition of half-pounders decreased proportionally in relation to the amount of time spent in freshwater. While residing in the river, half-pounders grow only about 1 cm in length. In comparison, cohorts remaining in the ocean grow about 15 cm during the same time interval (McPherson and Cramer 1982).

Although the potential for growth decreases, entry of half-pounders into freshwater may increase survival rates. At Cole M. Rivers Hatchery, less than 1% of the winter steelhead released as juveniles returned as adults. Conversely, adult returns from releases of juvenile summer steelhead averaged 2.8% (Evenson and Ewing 1984). This difference in survival rates may be attributable to a difference in life history strategies between the two races. While virtually all summer steelhead make half-pounder migrations, only 21% of scales taken from adult winter steelhead showed evidence of a half-pounder migration (McPherson and Cramer 1982).

Based on this evidence, I infer that the freshwater migration of half-pounders developed as a behavioral mechanism to reduce ocean mortality rates for summer steelhead produced in streams within northern California and southern Oregon. If this hypothesis is true, and the survival rate of half-pounders in freshwater is higher than the survival rate of cohorts remaining in the ocean, then there may be little or no adaptive advantage associated with the choice of which stream to enter.

During one summer, after a rare freshet breached sand bars blocking the mouths of two small streams on the southern coast of Oregon, survey crews collected half-pounders marked as smolts at hatcheries in the Klamath and Rogue river basins (Oregon Dept. of Fish and Wildl., Corvallis, unpubl. data). Such imprecise homing may reflect indiscriminate selection of streams to enter. Later, as maturation occurs, the precision of homing increases and acts as a behavioral mechanism which insures progeny rear in an environment for which they are adapted.

ACKNOWLEDGMENTS

This research composes a portion of the Rogue Basin Fisheries Evaluation Program which is funded by the United States Army Corps of Engineers, contract DACW57-77-C-0027. B. McPherson summarized much of the data and reviewed the manuscript. D. Lee provided information on releases of marked summer steelhead in the Klamath River basin. J. Ehmke typed the manuscript and D. Wahlstrom drew the figure.

LITERATURE CITED

Brannon, E. L. 1972. Genetic control of migrating behavior of newly emerged sockeye salmon fry. Int. Pac. Salmon Fish. Comm. Can. Prog. Rep. 16. 31. p.

Cramer, S. P., and B. P. McPherson [eds.]. 1982. Rogue Basin Evaluation Program. Adult Salmonid Studies. Annual Prog. Rept. Oregon Dept. of Fish Wildl., Fish Res. Proj. DACW-57-77-C-0027, Portland, OR.

Evenson, M. D., and R. D. Ewing. 1984. Cole Rivers Hatchery Evaluation. Annual Prog. Rept. Oregon Dept. of Fish Wildl., Fish Res. Proj. AFC-123-1-1 and AFS-78-1-1, Portland, OR.

Everest, F. H. 1973. Ecology and management of summer steelhead in the Rogue River, Oregon. Oregon State Game Comm., Fish Res. Rept. 7. Portland, Oregon.

Helle, J. H. 1981. Significance of the stock concept in artificial propagation of salmonids in Alaska. Can. J. Fish. Aquat. Sci. 38:1665–1671.

Hoar, W. S. 1976. Smolt transformation: evolution, behavior, and physiology. Can., Fish. Res. Board, J. 33:1234–1252.

Johnston, J. M. 1981. Life histories of anadromous cutthroat with emphasis on migratory behavior. Pages 123–127 in: E. L. Brannon and E. O. Salo, eds. Proceedings of the salmon and trout migratory behavior symposium, Univ. of Washington, Seattle, WA.

Jones, D. E. 1977. Life history of sea-run cutthroat trout in southeast Alaska. Alaska Dept. of Fish Game. Anadromous Fish Studies, Annual Perf. Rept., 1976–1977. Project AFS-42, 18 (AFS-42-5-B).

Kesner, W. D., and R. A. Barnhart. 1972. Characteristics of the fall-run steelhead trout (*Salmo gairdneri gairdneri*) of the Klamath River system with emphasis on the half-pounder. Calif. Fish Game, 58(3):204-220.

McPherson, B. P., and S. P. Cramer [eds.] 1982. Rogue Basin Fisheries Evaluation Program. Juvenile Prog. Rept. Oregon Dept. of Fish Wildl., Fish Res. Proj. DACW57-77-C-0027, Portland, Oregon.

Quinn, T. P., and K. Fresh. 1984. Homing and straying in chinook salmon (*Oncorhynchus tshawytscha*) from Cowlitz River Hatchery, Washington. Can. J. Fish. Aquat. Sci. 41:1078–1082.

Raleigh, R. F. 1967. Genetic control in the lakeward migrations of sockeye salmon (*Oncorhynchus nerka*) fry. Can., Fish. Res. Bd., J., 24:2613–2622.

Ricker, W. E. 1972. Heredity and environmental factors affecting certain salmonid populations. Pages 27–160, in: R. C. Simon and P. A. Larkin, eds. The stock concept in Pacific salmon. H. R. MacMillan Lectures on Fisheries,Univ. British Columbia, Vancouver, B.C.

Calif. Fish and Game 74(4): 208–217 1988

SHARK AGGRESSION AGAINST MAN: BEGINNINGS OF AN UNDERSTANDING:[1 & 2]

H. DAVID BALDRIDGE
3536 Brookline Drive
Sarasota, Florida 34239-4327

Over four decades of multidisciplinary studies provide an enlightened approach to understanding unprovoked shark aggression against man, particularly that against swimmers, divers, surfers, and fishermen in relatively shallow coastal waters. Incidence of attack is surprisingly low, and resulting injuries are most often survived. Attackers represent the full size range of predatory sharks. Any shark having both opportunity and physical capacity for injuring humans is considered dangerous. Attacks occur anywhere and anytime men encounter sharks, having higher probabilities related, but not necessarily causatively, to conditions favoring man's recreational use of the sea. The shark's limited arsenal for doing violence includes teeth for grasping and cutting, scaled hide for abrading, and momentum for forcing. Shark behavior and wound characteristics in totality convincingly suggest a high percentage of strikes against man are not determined efforts to devour humans as a prey of choice, being instead perhaps responses to motivations other than feeding. Such nonforaging aggressions have been observed in the field and lend themselves to credible explanation. To be effective, repellents and other antishark measures must cope with a multiplicity of shark motivations. New testing procedures need to be devised, giving full consideration to forces for aggression other than the feeding drive. Captured attackers should be carefully examined for anatomical, physiological, and biochemical anomalies.

INTRODUCTION

The early 20th-century concept of shark aggression against man was little more than a comfortably accepted blend of legend, ignorance, denial and apathy that had to be literally forced towards reality, slowly at first by the evolving means for rapid worldwide communication and then abruptly and urgently by the extensive military actions at sea of World War II. This position paper brings together much of what the author has come to believe about shark attack after many years as an officer of the United States Navy concerned with survival at sea, a chemist researching chemical repellents and physical repellers, an analyst of shark attack case histories, and, for a time, coordinator of shark repellent testing operations for the Office of Naval Research and the American Institute of Biological Sciences.

On 21 September 1931, a swimmer was savagely mauled by a hammerhead shark, *Sphyrna* sp., only some 60 m off the municipal beach at Palm Beach, Florida. That attack (Holaday 1931) is of particular historical significance to research on shark aggression against man. For as recently as about 50 years ago, the prevailing scientific opinion was that sharks, being cowardly scavengers, reserved their attention solely for the wounded and the dead, and, without being provoked, would not attack a live, uninjured man or woman.

---

[1] Presented in part as the Keynote Address for the Symposium on Shark-Human Interaction, 2nd Annual Meeting of the American Elasmobranch Society, Victoria, British Columbia, 18 June 1986.

[2] Accepted for publication July 1988.

This clearly unprovoked attack at Palm Beach was well witnessed and carefully documented. Irrefutability of the evidence led then prominent ichthyologist E. W. Gudger (1937) to raise the questioning counterview in his classic paper entitled "Will Sharks Attack Human Beings?". Gudger, then Associate Curator of Fishes at the American Museum of Natural History, concluded that "while attacks in our waters are rare, still, here and elsewhere, sharks sometimes do attack human beings."

Within only five years of almost reluctantly accepting the reality of unprovoked attack against man, American scientists hurriedly developed the since discredited chemical repellent, Shark Chaser, perhaps more to counter increasing fear rather than the actual fact of rampant attacks against survivors of air and sea disasters during World War II. Subsequent laboratory studies on the kinetics of responses by sharks to waterborne drugs (Baldridge 1969a) and mathematical analyses of the attack-repellent scenario (Baldridge 1969b, Johnson and Baldridge 1985, Baldridge and Johnson 1987) clearly indicate the inherent impracticability of perhaps any chemical for repelling an attacking shark when used in the classic continuous release mode.

Shark aggression and shark behavior did not again emerge as matters of significant concern to the scientific community until the late 1950's, with primary impetus provided by the Office of Naval Research of the United States Navy. A Shark Research Panel was organized to coordinate expanding interests in shark biology and to gather information on known occurrences of shark attack into what became widely known simply as the Shark Attack File (Gilbert 1963).

In spite of its recognized shortcomings, the Shark Attack File became in the 1960's and 70's the most extensive and intensive collection of shark attack information available for scientific study anywhere in the world. Although far from being a complete registry, records in the Shark Attack File probably represent for most analytical purposes at least a statistically valid, representative sample of known attacks. My close association with the Shark Attack File over the past 20 years has given rise to many of the herein presented basic tenets of my approach to understanding the very complex matter of shark aggression against man.

ATTACKS AND ATTACKERS

Site location and characteristics separate shark attacks into two general catagories; those happening in relatively shallow coastal waters, with the victims usually engaged in recreational activities, and those in deeper open-ocean waters, most often following air/sea disasters.

Shipwrecks, aircraft crashes, and other such violent tragedies at sea certainly have a far greater potential than near-shore recreational activities for exposing injured people to shark predation. Unfortunately, the available data on air/sea disasters are so limited and vague, or of such questionable authenticity, that efforts to analyze this most important category of attack have been essentially abandoned. So, shark attack in the present context is taken as that involving most often the live and uninjured swimmer, diver, surfer, fisherman, etc., in relatively shallow coastal waters.

Very likely because of rapidly decreasing availability of human potential victims in frigid waters at higher parallels, almost all unprovoked attacks have taken place between the latitudes of 47° S and 46° N. In some waters within these ill-defined boundaries, particularly those characterized by cold currents or low salinities, local shark populations are of limited species variation, of which only a few, at times even only one, present any real hazard to man. Such is the case with the white shark, *Carcharodon carcharias,* of recent motion picture and television infamy, which has very few competitors in cold waters such as found off California and Oregon. It would certainly be true in numerous fresh water rivers and lakes around the world where variations of the bull shark, *Carcharhinus leucas,* constitute the one and only threat of attack. Lea and Miller (1985) noted such limited species involvements in Pacific Ocean waters off California and Oregon during the 58-yr period of 1926–1984, in that 78% of 59 documented attacks were attributed to the white shark. In these relatively cold waters, the potential for such attacks is apparently evolving upward in response to ready availability of natural prey species and perhaps especially to expanding intrusion into the milieu of white sharks by humans bent on some form of water sport made more enjoyable in recent decades by the thermal insulation of wet suits.

On the other hand, in warmer waters more generally and heavily utilized by man, the hazard is multifaceted in terms of both size and species of potential attackers. Local shark populations, when considered as a whole, at times show a more or less bell-shaped distribution in regard to size, with each individual species apparently occupying its own size-niche in some shared scheme of things. For example, I once found (Baldridge 1968) 1006 sharks of 13 species collected from the Gulf of Mexico off west central Florida over a 9-yr period to show a reasonable Gaussian distribution of size around a mean total length of about 2.2 m (just over 7 ft). Such a finding is consistent with the hypothesis of Springer (1960) that groups of similarly-sized sharks in certain areas often constitute segments of a single interacting system involving many species, wherein competition would be primarily among sharks of comparable size rather than members of the same species. In such waters, the hazard of attack would become as much, if not more, a matter of animal size as any regard for one or more particularly "dangerous" species of sharks.

For most of my analytical purposes (Baldridge 1973, 1974a, 1974b, 1975), shark attack has been considered to be any forceful or injurious exchange between a person and any shark. Because of the evolving nature of predator-prey relationships vis-a-vis sharks and humans, Lea and Miller (1985) rightfully recommended caution in comparing early shark attack information with more recent data. There is also the clear need for extreme care and circumspection in comparing, without appropriate qualifications, results of any and all analyses of shark attack data performed either on distinctly different data bases or on nonrepresentative or otherwise incommensurable segments of a larger data base. Analyses limited in scope to attacks by certain species, size ranges, or geographical distributions would very understandably produce results differing at times very significantly from those reflecting the total data base. For example, the analyses and somewhat different (from mine) findings of Miller and Collier (1981) and Lea and Miller (1985) were concerned almost exclusively with patently one-sided exchanges between swimmers, divers, and surfers and the white sharks that frequent cold waters of the Pacific Ocean off northern California and Oregon. Nevertheless, there are some factors that I suspect to be so innately and generally involved with shark attack that they are considered to transcend to reasonable degrees many of the distinctions imposed by species and/or geographical differences.

In order for a shark attack to occur, a shark and a person must be brought together, usually, but not always, in the water. Some "victims" have been injured out of the water by captive sharks held in nets or incautiously brought abroad a boat or dock. Since the sharks are apparently already there in plentiful supply, the determinant for shark attack is reduced to getting people into the water. So, over the years, a host of correlations have been developed that represent nothing more than conditions under which greater numbers of people present themselves for attack, most often by using the sea for recreational purposes. As prime examples, it is true, but certainly not in any sense of cause-and-effect, that most attacks occur during the afternoon hours, on days of pleasant weather, and that most attacks at beaches occur in waters that are waist deep or less. Even more to the point of ready availability of potential victims, about two-thirds more attacks occur on each of the weekend holidays of Saturday and Sunday than on the traditional working days of the week.

There is, however, one environmental factor that is still firmly believed by some to bear a true cause-and-effect relationship to shark attack, and that is water temperature, with attack considered very unlikely below a "critical temperature" of about 20–21° C (68–70° F) proposed by Coppleson (1962) and Davies (1965). Over a fifth of all reported attacks where water temperatures were either known or estimated have happened in waters colder than 20–21° C, including many if not all those occurring in waters off California and Oregon. It does not seem reasonable that a variety of shark species apparently function well, or at least adequately survive, at sea temperatures ranging around the world from near freezing to well over 32° C(90° F), and yet their collective aggressive behavior towards man would be so thermostatically controlled as to have a sharp cut-off point below 20–21° C.

On the other hand, the extent of man's use of the sea, and hence his availability for attack, is certainly closely related to temperature—for very important reasons of basic human physiology as well as comfort. It is well known that humans, unprotected by wet suits, are very reluctant to spend much time in waters colder than 20° C. This is simply because metabolic processes cannot maintain satisfactory levels of body heat at lower water temperatures, leading to hypothermia. In an effort to get some control data on this point, I once arranged for yearlong counts of bathers at two popular resort beaches (Siesta Key, Florida and Myrtle Beach, South Carolina) where water temperatures ranged from about 12 to 32° C (53–89° F). We found that only about 8% of over 21,000 bathers counted were in waters colder than 21° C(70° F). It logically follows that the probability of a shark encounter leading to an attack at such beaches would be far greater in waters warmer than 21° C, simply because there are far fewer people available for attack in colder waters. So, if there is a true "shark attack season" based directly on sea temperature, it would most likely be that period of time when the temperatures in a particular area range from about 20–21° C to about 29–30° C; that is, when it is warm enough for humans but not too hot for sharks.

Now, of course, the physiologically mandated minimum temperature requirement for humans can be lowered very significantly by the thermal insulation of a wet suit. Hence, we find increasing numbers of attacks against divers and surfers who unwittingly—or witlessly—dress themselves in black wet suits to resemble local shark prey items (seals, sea lions, etc.) in cold waters around the world, including those found off California and Oregon (Tricas and McCosker 1984, McCosker 1985).

An attacker shark certainly does not have to be large in order to inflict severe, even fatal wounds. Known attackers represent essentially the full size range of predatory sharks, from only about 45 cm to over 6 m in length. The median total length of 2.1 m (just under 7 ft) calculated for attackers is practically identical to that of 2.2 m found for the general shark population of the Gulf of Mexico off the central west coast of Florida (Baldridge 1968). Thus, only slightly more than half of known attackers, as well as members of at least one control coastal population, were found to be greater in length than the height of a moderately tall man. So, rather than to point accusingly at such particularly guilty species as the white shark or tiger shark, *Galeocerdo cuvieri,* we should consider essentially all sharks as potential attackers of man. No shark of any size or species should ever be placed in a situation so untenable that the animal has no alternative but to strike out in defense. Realistically, the label of "dangerous shark" should apply to any individual or species that has both the opportunity and the physical capacity for inflicting harm on humans.

ATTACK MECHANICS

A shark is truly an integrated weapons system, with an arsenal for doing violence that is very effective even if somewhat limited; teeth for grasping and cutting, scaled hide for abrading and tearing, and momentum for forcing and stunning.

Aside from using the teeth for biting, many sharks can do considerable damage by raking a victim with the upper teeth, bringing sharp edges to bear in a knife-like fashion as the head and open mouth are moved from side to side. Even though the resulting cuts or slash-type wounds are at times very severe, they are often received by victims with little or no pain and no significant loss of flesh. On the other hand, considerable loss of tissue has been caused occasionally by rubbing contact between the victims and the very abrasive hides of rapidly moving sharks; the hides of many sharks dangerous to man being covered with tiny scales having the same basic structure as teeth.

Direct head-on bumps, as contrasted to glancing blows producing abrasive contacts, are sometimes delivered by large sharks with such force that their victims are actually propelled vertically into the air, free of the water. Witnesses have described this phenomenon as if the victim had suddenly stepped up onto a rock although in deep water at the time.

Large, heavy sharks are lightened considerably when submerged because of buoyancy provided by displaced sea water and enhanced to a significant degree by low density oils held in their huge livers (Baldridge 1972). On the other hand, the mass of a shark, unlike the apparent weight, remains constant regardless of whether the shark is in air or water. Mass and swimming speed are the elements of momentum, and momentum gives the shark, particularly a large shark, a very valuable capacity for aggressively applying force to another animal; for example, to stun or rapidly immobilize prey or other targets of aggression. Momentum would actually be of much greater value to a rapidly swimming smaller shark than to a relatively lethargic larger individual swimming at a lesser speed. The kinetic energy available for transfer from a moving shark to a stationary victim is a function of shark mass only to the first power, but swimming speed to the second power.

McCosker (1985) noted the role of momentum in predatory strategies employed by white sharks (2.5 – 5.5 m, total length). Adult white sharks were considered as ungainly and insufficiently maneuverable to catch most smaller, more agile healthy species, and so must attack their prey by surprise, attempting to immobilize it at first contact. Consequently, the initial strike often takes the form of a combination of ramming and biting, with the shark rapidly ascending from beneath and behind the victim, be it pinniped or human, grasping it in a crushing bite, causing both shark and prey to rise above the surface with the sudden transfer of kinetic energy. Quite often, the victim is just as suddenly released, and the shark retreats, apparently to wait for the devastating effects of both ramming and biting to render the prey defenseless. Fortunately, for many human victims with companions nearby, this momentary respite is sufficient for effecting rescue.

Abrasive rubs and head-on bumps are usually considered as incidental contacts by the shark in rushing headlong towards its intended victim, or, if intentional, as tentative probes by the shark to test the identity or edibility of unfamiliar prey. It seems equally logical, however, that such contacts are intentionally aggressive strikes, and that attacking sharks, are aware of the potential of both rubbing and ramming for incapacitating another animal or effecting changes in its behavior.

Instead of devouring their victims as popular literature and motion pictures would have it, most attackers strike humans only once or twice, resulting in an equivalent number of wounds or sets of injuries. An estimated 80% or more of all present-day victims will survive being attacked by sharks. Furthermore, in only about 20 to 25% of documented attacks did either behaviors of the sharks or wound characteristics indicate determined efforts to "finish off" the victims; that is, where the sharks either exhibited wild, frenzied behavior or delivered multiple strikes in a deliberate, methodical manner. Such attacks by hyperactive or unrelenting sharks differ markedly from the more frequent, far less violent single-event encounters, in that wounds are often massive and extensive, resulting in a much higher mortality rate.

In almost half the attacks on record, there was no significant loss of tissue by the victims. The surprisingly limited array of wounds reported for attacks in general, and those of lesser ferocity in particular, is not at all consistent with determined efforts to attack, kill, and devour humans as a prey of choice. While there are indeed those cases where sharks did in fact devour their victims, either partially or totally, there are many more instances of sharks acting aggressively towards man that are very difficult to accept as legitimate attempts to feed.

ATTACKER MOTIVATION

Could it be in the past that we have occasionally rushed to judgement in terms of shark motivation? Perhaps our ideas about the Beginning of an attack have been shaped far too often by knowledge only of the Ending, especially when the shark actually removed and ingested flesh of the victim. Tissue loss by a victim has just about always been taken as *prima facie* evidence of attack by a hungry shark. Yet, the character and extent of damage done to the victim might not be a true reflection at all of the factors that motivated the shark to initiate the attack, any attack, even one involving dismemberment of the victim.

It was just such misgivings about attacker intentions, arising during the study of some 1700 case histories, which led me to propose (Baldridge and Williams, 1969) that perhaps 50 to 75% of all documented attacks against man might have been motivated by drives other than feeding.

Such attacks, which I prefer to call nonforaging aggressions, could conceivably have been responses by sharks to such inadvertent provocations as:

(i) interference by the victim in courtship or pupping behavior of a shark—thereby drawing an agitated, perhaps hormonal, response,

(ii) the victim appearing as a threat or as competition in the form of an unfamiliar presence, or the sudden presentation of something unfamiliar, or the disquieting body language or semiochemical signature of an unfamiliar presence—to which the shark responds with a preemptive strike,

(iii) trespass of a shark's territorial limits in terms of space, or approach distance, or approach speed—eliciting from the shark a defensive strike or some other effort to establish dominance.

Keep in mind that we are considering here mainly attacks in relatively shallow coastal waters. Feeding might very well be the primary motivation for attacks in the open sea, where the time scale is heavily in favor of the sharks, natural food is less plentiful, and the hapless human in the water might simply become nothing more than prey of opportunity. There is, of course, no sharp line of demarkation between coastal waters and the open ocean, particularly where large sharks are involved.

The earliest authoritative documentation known to me of a clear example of nonforaging aggression was that which described an injurious attack by a Pacific grey reef shark, *Carcharhinus menisorrah,* off Wake Island in 1961, in direct response to territorial insults by a diver (Church 1961). Furthermore, the provoked shark evidently clearly announced its agitation and threat of attack by "turning its head back and forth and swimming in an erratic manner." Such agonistic displays and subsequent strikes by Pacific grey reef sharks, for objectives clearly not directly related to the procurement of food, have been studied extensively following Johnson and Nelson (1973).

The physical means available to sharks for effecting nonforaging aggression are exactly the same as those used for the procurement of food; namely, their teeth, rough hides, massive bodies, speed and agility. It then should be no surprise that the results occasionally become one and the same also for the victims, particularly where the attackers are very large sharks.

Having no voice with which to communicate or to warn other animals, sharks are reduced to direct action for purposes of neutralizing real or perceived threats, establishing dominance, or otherwise exerting influence for change. Such direct physical exchanges, particularly those involving large sharks, are inherently violent, and, when directed towards relatively fragile human beings, would be expected more often than not to produce injury, including significant loss of tissue. If the sharks are relatively unexcited in initiating nonforaging aggression, a minimum of flesh is removed, and the wounds are more likely to be single bites, abrasions, or lacerations of a slash type. As excitement increases, either when initiating or conducting the attack, so does the number and severity of wounds as well as the likelihood of flesh being lost and ingested. An extremely agitated nonforaging aggressor is thus indistinguishable from a frenzied feeder. Human objects of this intense level of physical battery then simply become something to be repeatedly assaulted, bitten again and again, and very likely ingested, even if the attacks were not initially motivated by the feeding drive.

The removal and ingestion of flesh by an attacking shark could very well then be more in evidence of the shark's limited repertoire for doing violence than *prima facie* proof that the shark was in the feeding mode when it initiated the attack.

IMPLICATIONS FOR ANTISHARK MEASURES

Since nonforaging aggressions can be equally as devastating to victims as feeding strikes, original intentions of the shark would appear to be of little concern to a man in the water. Nevertheless, the question of shark motivation at the outset of an attack remains critical to the development of effective antishark measures. If we are ever to be successful in preventing or even significantly mollifying the dreadful outcome of shark attack against man, it is the outset of the attack and the multiplicity of aggressive drives available to the sharks with which we must contend.

Because of past widespread acceptance of shark attacks simply as efforts by sharks to feed on man, repellents and other antishark measures have been routinely evaluated under feeding conditions. The feeding drive might very well prevail in open-ocean situations, where the use of repellents for individual protection would be more appropriate. Nevertheless, increasing suspicions that nonforaging aggression could be the trigger for a very significant fraction of attacks in general indicate a clear and pressing need for modification of those testing procedures that rely solely on discouraging the taking of attractive bait by starved sharks. In fact, very different approaches to antishark measures should be developed depending upon whether primary concern is with attacks in the open sea or in coastal waters; that is, whether motivation for attack is more likely to be "feeding or fighting." Nelson (1983) comprehensively analyzed the perhaps insurmountable burdens that have been placed on repellency research by ever increasing recognition of the inherent complexities that govern aggressive behavior by sharks.

DISCUSSION

It will be no easy task to identify further and then reproduce under controlled conditions, either in the laboratory or the open sea, those drives, other than feeding, that could occasionally trigger sharks to attack men and women without overt provocation. Perhaps some early studies (Menichelli and Schwartz 1966, Baldridge 1969a) using highly toxic antishark agents might offer a clue to the pharmacologically or biochemically inclined.

Narcotizing or anesthetizing drugs in general first elicit in sharks excitation and then depression, before leading to immobilization. For example, anyone who has used MS-222 (the methanesulfonic acid salt of tricaine, ethyl

3-aminobenzoate) to anesthetize a large shark has seen the stimulation that precedes sedation. Such excitement and hyperactivity are far more intense with the tobacco alkaloid, nicotine. Juvenile lemon sharks, *Negaprion brevirostris,* became extremely agitated when placed in tankwater containing nicotine, dashed about and attempted to bite anything that blocked their paths, such as the drainpipe or a stick placed in their way. During the few minutes before succumbing to a lethal injection of nicotine, an adult lemon shark literally destroyed its teeth on the wire fence that blocked its escape.

The point here is that aggressive shark behavior, randomly directed and totally unrelated to feeding, has already been elicited by chemical means in the laboratory. And, the significance of this point is that, if intensively aggressive behavior can be elicited by exposure of a shark to an exogenous chemical, there should be no reason why the shark could not do it to itself with an endogenous chemical, or perhaps an imbalance of endogenous chemicals.

A distinct possibility for such biochemical imbalance would be a transitory excess of the sex hormone, testosterone, in male sharks. The males of many animal species are certainly known to engage in intense nonforaging aggression; the strutting rooster, the charging male elephant, the fighting bull, etc. Yet, with sharks, we not only know nothing at all about hormone levels in attackers, we do not even know if attackers happen to be predominantly male or female. The sex of a known attacker has been only very rarely noted, even when the shark was captured in direct association with an attack and thus available for close examination.

Future captured attackers certainly should be studied in minute physical and chemical detail. Perhaps unprovoked aggressions are extremely rare, considering the ready availability of potential human victims, simply because the attackers themselves are exceptional oddities due to some infrequently occurring anatomical, physiological, or biochemical anomaly. For example, the 2.5-m white shark, that in 1966 attacked a boy at Coledale Beach, Australia, was captured affixed to the leg of the victim and found to have been very likely severely handicapped in seeking normal prey by massive abdominal wounds recently inflicted on it by another shark (Short 1966). In the same sense, I once suggested (Baldridge 1972) that aberrant biochemistry leading to inappropriate deposition of buoyant liver oil and resultant degradation of hydrostatic balance might cause a shark to seek less agile prey, perhaps in the form of an unluckily available human.

CONCLUSIONS

Almost a half-century of study by scientists of many disciplines has proven Gudger (1937) correct in his concession that "sharks sometimes do attack human beings," inflicting serious injury and death on scores, perhaps even hundreds, but certainly not thousands of people around the world each year.

We now recognize reasons for shark attack to be far more complicated than just a wild animal satisfying a gnawing hunger. Acknowledgement of a multiplicity of motivations for initiating attacks does not diminish in any way the shark's potential for violence nor should it lead any person to abandon caution, which remains the absolute watchword of Any encounter with a shark of Any size or Any species.

On the other hand, such a multiplicity of aggressive drives complicates immensely the task of developing effective antishark measures, including in particular the elusive, perhaps even delusive, chemical shark repellent. And, this situation is not likely to be improved significantly until that distant time when we are in possession of as much knowledge about attackers as we now have about victims.

Considering the increasingly great numbers of people who enter the sea each year and the plentiful presence in those same waters of sharks, many possibly very resentful of such trespasses, a question perhaps far more challenging to modern and future shark researchers than that faced by Gudger over 50 years ago would be—**Why Don't Sharks Attack Human Beings Far More Often?**

LITERATURE CITED

Baldridge, H.D. 1968. A proposed reference shark. Milit. Med., 133:654–662.

________. 1969a. Kinetics of onset of responses by sharks to waterborne drugs. Bull. Mar. Sci., 19:880–896.

________. 1969b. Analytic indication of the impracticability of incapacitating an attacking shark by exposure to waterborne drugs. Milit. Med., 134:1450–1453.

________. 1972. Accumulation and function of liver oil in Florida sharks. Copeia, 1972:306–325.

________. 1973. Shark attack against man: a program of data reduction and analysis. Final Report, Office of Naval Research, Contract N00014-73-C-0252. Mote Marine Laboratory, Sarasota, FL. 94 p. (Report AD 771039, Defense Documentation Center, Arlington, VA.)

________. 1974a. Shark attack: a program of data reduction and analysis. Mote Marine Lab., Contri., 1(2). 98 p. (partial reprint of Baldridge, 1973).

________. 1974b. Shark attack. Droke House/Hallux, Inc., Anderson, SC. 297 p.

________. 1975. Shark attack. Berkeley Publishing Corp., New York, NY. 263 p. (paperback edition of Baldridge, 1974b).

________AND C.S. Johnson. 1987. Antishark warfare? U.S. Naval Institute Proceedings, 113(12):119–120.

________AND J. Williams. 1969. Shark attack: feeding or fighting? Milit. Med., 134:130–133.

Church, R. 1961. Shark attack. Skin Diver, June (1961):30–31.

Coppleson, V.M. 1962. Shark attack. Angus and Robertson, Sydney. 269 p.

Davies, D.H. 1965. About sharks and shark attack. Brown, Davis, and Platt Ltd., Durban. 237 p.

Gilbert, P.W. 1963. The AIBS shark research panel. Pages 505–507 *in* P.W. Gilbert, ed. Sharks and survival. D.C. Heath and Co., Boston.

Gudger, E.W. 1937. Will sharks attack human beings? Nat. Hist., 40(1):417–418.

Holaday, G. 1931. Shark Attack File case No. 217, 21 September 1931.

Johnson, C.S. AND H.D. Baldridge. 1985. Analytic indication of the impracticability of waterborne drugs for repelling an attacking shark. Technical Document 843. Naval Ocean Systems Center, San Diego, CA. 12 p.

Johnson, R.H. AND D.R. Nelson. 1973. Agonistic display in the grey reef shark, *Carcharhinus menisorrah,* and its relationship to attacks on man. Copeia, 1973:76–84.

Lea, R.N. AND D.J. Miller. 1985. Shark attacks off the California and Oregon coasts: an update, 1980–84. S. Calif. Acad. Sci., Memoirs, 9:136–150.

McCosker, J.E. 1985. White shark attack behavior: observations of and speculations about predator and prey strategies. S. Calif. Acad. Sci., Memoirs, 9:123–135.

Menichelli, V.J. AND S.L. Schwartz. 1966. Observations of sharks subjected to various poisons. Special project report. Naval Medical Research Institute, Bethesda, MD. 16 p.

Miller, D.J. AND R.S. Collier. 1981. Shark attacks in California and Oregon, 1926–1979. Calif. Fish Game, 67(2):76–104.

Nelson, D.R. 1983. Shark attack and repellency research: an overview. Pages 11–74 *in* B.J. Zahuranec, ed. Shark repellents from the sea, new perspectives. AAAS Selected Symposium 83, American Association for the Advancement of Science, Washington, D.C.

Short, R. 1966. Shark Attack File case No. 1406, 26 February 1966.

Springer, S. 1960. Natural history of the sandbar shark, *Eulamia milberti.* U.S. Fish and Wildl. Serv. Fish. Bull., 178(61):1–38.

Tricas, T.C. AND J.E. McCosker. 1984. Predatory behavior of the white shark, *Carcharodon carcharias,* with notes on its biology. Calif. Acad. Sci., Proc., 43(14):221–238.

Calif. Fish and Game 74(4): 218–225 1988

COMPARATIVE HOOKING MORTALITY OF LURE-CAUGHT LAHONTAN CUTTHROAT TROUT AT HEENAN LAKE, CALIFORNIA [1]

ROBERT G. TITUS [2] AND C. DAVID VANICEK

Department of Biological Sciences
California State University, Sacramento
Sacramento, California 95819

Mortality of lure-caught Lahontan cutthroat trout, *Salmo clarki henshawi,* from Heenan Lake, California, was evaluated in relation to hook type, water temperature, hooking site, and fish size. Trout were caught by angling with hardware lures having either a single barbless, treble barbless, or treble barbed hook. Fish were held in live boxes in the lake for 96 h following hooking to assess mortality. Mortality was less than 1.5% at water temperatures between 5.5° C and 15.5° C, but rose to nearly 50% as the temperature approached 21.0° C. Differential mortality among hook types was apparent only during the high-temperature period, when highest losses (59.1%) occurred with fish caught with single barbless hooks. Thus, this study supports the view that a single barbless hook only regulation in catch-and-release waters is unnecessary. Effect of anatomical hooking site could not be assessed, since 87% of all trout were hooked in either the upper or lower jaw. Mortality did not vary significantly with fish size.

INTRODUCTION

The California Department of Fish and Game (CDFG) now manages several catch-and-release fisheries to meet increased demands for quality angling opportunities. This management practice is based on the assumption that fish released by anglers will survive to be caught again, to spawn, or to reach larger sizes. To simplify the state's fishing regulations, the CDFG implemented a "single barbless hook only" regulation on all catch-and-release trout fisheries, based on the assumption that it would reduce hooking injury and mortality. Several studies, however, (Hunsacker, Marnell and Sharpe 1970; Falk, Gilman and Dahlke 1974; Bjornn 1975) indicated that barbless hooks on lures do not significantly lower mortality. Substituting single hooks for treble hooks on lures has caused higher mortalities (Klein 1965; Warner 1976, 1978). Thus, it may be inappropriate to use a single barbless hook regulation for managing California's wild trout fisheries. Other factors which may affect survival of hooked-and-released fish are water temperature, anatomical hooking site, and fish size (Wydoski 1977).

To provide more information on the validity of the single barbless hook regulation for managing catch-and-release trout fisheries, a hooking mortality study was conducted on Lahonan cutthroat trout, *Salmo clarki henshawi,* in Heenan Lake, California. The objective of this investigation was to compare hooking mortality of lure-caught Lanontan cutthroat trout by (i) hook type (single barbless, treble barbed, and treble barbless); (ii) water temperature; (iii) fish size; and (iv) anatomical hooking site.

---

[1] Accepted for Publication May 1988

[2] Present Address: Institute of Limnology, Box 577, S-75122 Uppsala, Sweden.

STUDY AREA

Heenan Lake (Figure 1) is in the East Carson drainage, Alpine County, California, at 2,164 m elevation and 11.3 km southeast of Markleeville. It was formed by a dam built on Heenan Creek in 1925 and has a maximum surface area of 56.3 ha and maximum depth of 9 m. Surface water temperatures range from 21° C in summer to 0° C in the winter under the ice cover. The lake serves as California's broodstock reservoir for hatchery propagation of Lahontan cutthroat trout, which is the only fish species present. Unlike most Sierra lakes, the lake is highly eutrophic (Calhoun 1942). The CDFG purchased Heenan Lake in 1983, and has added the lake to its catch-and-release program on an experimental basis.

METHODS AND MATERIALS

In 1983, hooking mortality in relation to terminal gear type in three different water temperature ranges was assessed during three different periods: (i) June 3–5, the "coldwater" or spring period; (ii) July 29–31, the "warmwater" or summer period; (iii) September 23–25, the "moderate" or fall period.

Temperature and dissolved oxygen (DO) profiles were measured to characterize the basic limnological conditions in the lake during each survey. Temperature readings were taken at various depths in the deepest part of the lake with an electronic thermometer. Corresponding DO determinations were made to the nearest 0.1 mg/l with the azide modification of the Winkler method.

Lahontan cutthroat trout were caught by hook-and-line with 7.1 g Phoebe-brand hardware lures with size no. 6 hooks. The lures were gold or silver, and had either a single barbless, treble barbless, or treble barbed hook attached. Fishing was conducted primarily from boats either by casting or slow, shallow trolling. The fish were generally concentrated in the upper half of the water column so casting and trolling depths ranged from about 1 m to 4 m.

To assure standardization, anglers were instructed to play each hooked trout for 1 to 2 min before netting. The fish were then placed in a tub of fresh lake water and the hooks removed. The anatomical hooking site on each fish was noted by a temporary caudal fin punch which designated, by location on the fin, one of five basic sites: (i) upper or lower jaw; (ii) roof of mouth; (iii) eye; (iv) gill or gill arch; and (v) isthmus, tongue, or throat. The day of capture (first, second, or third) was indicated by an additional fin punch. The fish were then placed into a floating live box (3.4 m^3) constructed of wood and hardware cloth. Each live box contained trout caught on only one hook type. All these steps were executed as swiftly as possible to minimize stress.

To measure delayed mortality, all trout were held in live boxes for 96 h following hooking. In the spring survey, the live boxes were placed in the littoral zone near the east shore of the lake, south of the Heenan Creek inlet (Figure 1). During the summer and fall surveys, when water temperatures were higher, the live boxes were placed near the mouth of Heenan Creek which provided a source of cool, well-oxygenated water. Water temperature and DO concentrations were monitored at this site during the summer and fall surveys. At the conclusion of the 96 h period, the surviving trout were netted from the live boxes and anesthetized with tricaine methanosuphonate. The following data were collected from each fish: fork length (mm), weight (g), hook type on which the fish was caught, and anatomical hooking site. These data were also collected for all trout found dead during the 96 h holding period.

Goodness-of-fit tests were performed with chi-square contingency tables as described by Snedecor and Cochran (1967) to test the null hypothesis that hooking mortality was independent of water temperature, hook type, and fish size.

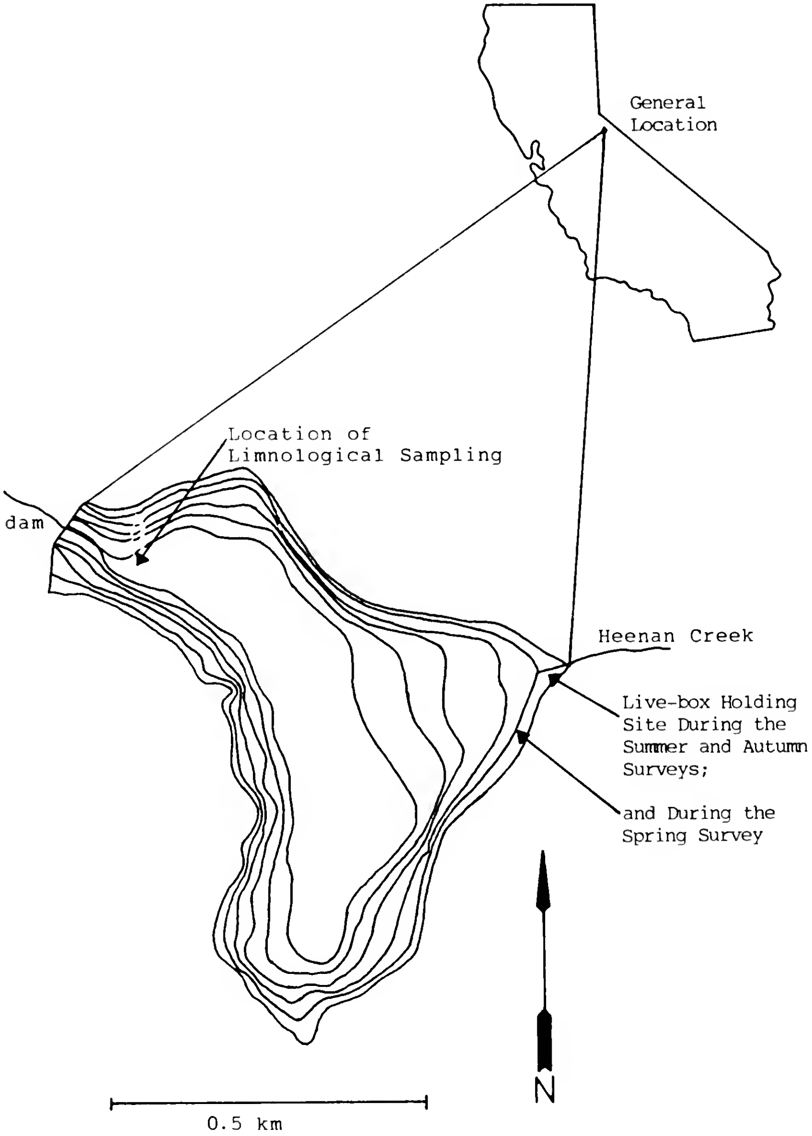

FIGURE 1. Map of Heenan Lake, Alpine County, California.

RESULTS AND DISCUSSION

Limnological Conditions

The June survey occurred only 3 to 4 weeks after the ice had melted, and the lake was just beginning to stratify. The upper epilimnion was well mixed; afternoon water temperatures from 2 m depth to surface ranged only from 10.0° C to 11.0° C, and DO concentrations from 8.0 to 10.0 mg/l. Water temperature at a depth of 5.5 m was 5.5° C, and DO was 6.7 mg/l. Bottom temperature and DO were 4.0° C and 2.9 mg/l, respectively.

The lake was stratified during the summer survey, and the thermocline began at about 5 m depth. Epilimnion temperatures ranged from 14.0° C at 5 m to a diel maxima of 21.0° C at the surface in the littoral zone. Epilimnion DO concentrations ranged from 8.0 mg/l at 5 m to a diel maxima of 10.0 mg/l at the surface in the littoral zone. Temperature and DO at the bottom were 6.0° C and 0.1 mg/l, respectively.

During the September survey, the fall overturn had begun and conditions in the upper 6 to 7 m of the water column were relatively uniform. Temperatures varied only 2.5° C, from 13.0 to 15.5° C, and DO ranged from 8.5 to 10.0 mg/l. Bottom temperature and DO were 10.5° C and 0 mg/l, respectively.

Numbers and Sizes of Trout Caught

A total of 533 trout was caught, ranging in fork length (FL) from 211 to 545 mm (Table 1). During the spring survey, the caught fish were larger ($\bar{x} = 436$ mm FL) and more numerous ($n = 282$) than in the summer ($\bar{x} = 373$ mm FL; $n = 169$) or fall surveys ($\bar{x} = 389$ FL; $n = 82$) because fishing occurred while mature trout were migrating into Heenan Creek to spawn. These adult fish were readily caught as they concentrated near the creek mouth. Fewer adult fish, but more juvenile fish, were caught in the summer and fall surveys, as the fish were dispersed throughout the lake. Poor visibility due to phytoplankton blooms may also have reduced summer and fall catches.

TABLE 1. Numbers and Lengths of Lahontan Cutthroat Trout Caught on Lures at Heenan Lake, California During Spring, Summer, and Fall. 1983.

Survey Period	*Number Caught*	*Fork Length (mm)*	
		Mean ± SD	*Range*
June 3–5	282	436 ± 44	260 - 545
July 29–31	169	373 ± 63	235 - 491
Sept. 23–25	82	389 ± 74	211 - 525

Hooking Mortality

Mortalities of hooked trout were only 1.4% and 1.2%, respectively, during the spring and fall surveys (Table 2). However, a mean hooking mortality of 48.5% occurred during the summer period when surface water temperatures reached a peak of 21° C. These differences in mortality were highly significant [$X^2 = 187.79$; 2 df; $p < 0.005$]. We therefore rejected our null hypothesis and attributed the high mortality during the summer survey to increased stress caused by the high water temperatures. DO concentrations were similar during all periods. Other studies (Benson and Bulkley 1963; Klein 1965; Hunsacker et al. 1970; Dotson 1982) reported positive relationships between water temperature and hooking mortality, although reported mortalities and corresponding temperatures were lower than in our study. Benson and Bulkley (1963) observed an increase in mortality of lure-caught Yellowstone cutthroat trout from 0.7% during the spring spawning season to 21.3% in mid-summer. Summer surface temperatures in Yellowstone Lake rarely exceeded 18° C which is well below the peak temperature of 21° C that occurred at Heenan Lake. For the Lahontan cutthroat trout, this temperature difference may be significant. Vigg and Koch (1980) determined the upper lethal temperature range for juvenile Lahontan cutthroat trout to be 21.8° C to 23.0° C. Stress symptoms, feeding inhibition, and loss of equilibrium occurred at slightly lower temperatures. The authors suggested there may be a size effect or differential temperature tolerance among forms of *Salmo clarki* since Dwyer and Kramer (1975) found that larger cutthroat trout could tolerate 24° C; however these fish were near their upper lethal temperature and had stopped feeding.

TABLE 2. Mortalities of Heenan Lake Lahontan Cutthroat Trout Caught on Lures by Hook Type and Period, 1983.

			Mortalities	
Survey Period	*Hook Type*	*Catch*	*Numbers*	*%*
June 3–5	Single Barbless	110	0	0
	Treble Barbless	95	2	2.1
	Treble Barbed	77	2	2.6
	Subtotals	282	4	1.4
July 29–31	Single Barbless	66	39	59.1
	Treble Barbless	51	18	35.3
	Treble Barbed	52	25	48.1
	Subtotals	169	82	48.5
Sept. 23–25	Single Barbless	26	0	0
	Treble Barbless	29	1	3.5
	Treble Barbed	27	0	0
	Subtotals	82	1	1.2
	TOTALS	533	87	16.3

To provide a more comprehensive picture of the relationship between hooking mortality of lure- and fly-caught trout and water temperature, we have combined data from the literature with the results of this study (Figure 2). Peak temperatures were used in all cases, and data for both cutthroat and rainbow trouts were included since these species are ecologically similar and respond equally to fishing stress. The point which indicates 100% mortality at 24° C is theoretical and based on results from Vigg and Koch (1980) and Dwyer and Kramer (1975). Significant levels of mortality ($>20\%$) occurred above 17° C. Below this temperature, mortalities were 10% or less. This relationship could be better defined with additional catch-and-release experiments at water temperatures from 16 to 24° C.

Hook Types

Differences in levels of mortality were also apparent among the three hook types in the summer survey (Table 2); the highest mortality (59%) was associated with the barbless single hook, the next highest with the barbed treble hook (48.1%), and the lowest mortality with the barbless treble hook (35%). We used a 2x3 contingency table to test the hypothesis that mortality was independent of hook type. The computed X^2-value of 6.54 was significant at $p<0.050$; thus, the hook types did appear to result in significantly differentlevels of mortality under the high temperature conditions.

Klein (1965) observed no difference in mortality of rainbow trout (*Salmo gairdneri*) hooked with treble and single hooks at Parvin Lake at 6.5° C, but at 14.5° C, lures with single hooks cause about double the mortality of treble hooks. Warner (1978) reported no significant difference in mortality of Atlantic salmon caught on lures with single or treble hooks. Falk et al. (1970), Hunsaker et al. (1970), and Bjornn also concluded that barbless hooks did not reduce hooking mortality.

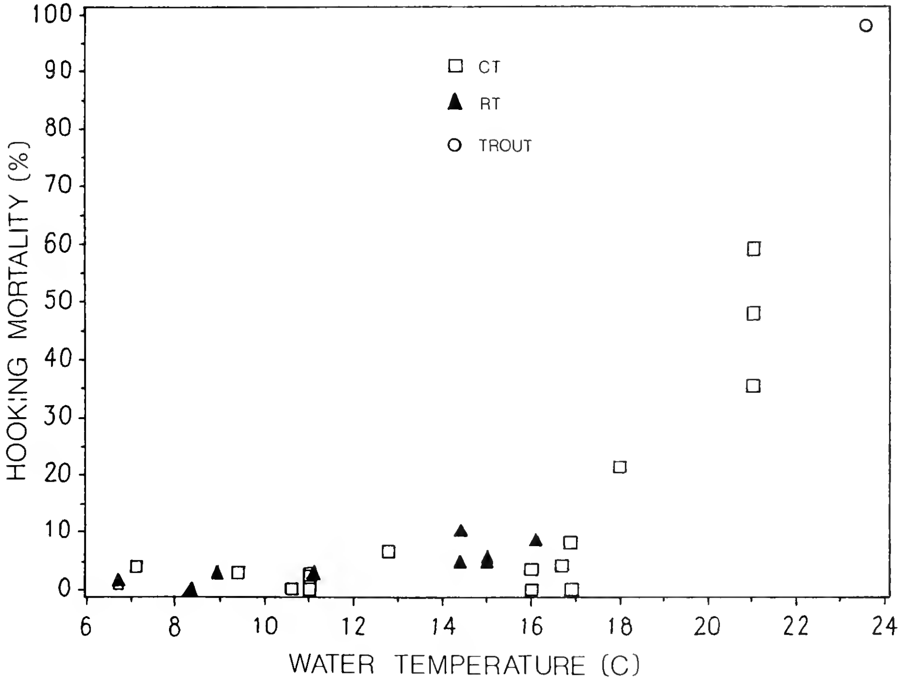

FIGURE 2. Relationship between hooking mortality of cutthroat and rainbow trouts and water temperature. CT = cutthroat trout, RT = rainbow trout, TROUT = theoretical cutthroat trout at 24° C. Data taken from Benson and Bulkley (1963), Klein (1965), Hunsaker et. al. (1970), Marnell and Hunsaker (1970), Dotson (1982), and this study.

Size of Fish

Because post-spawning stress can cause high mortality of adult cutthroat trout (Ball and Cope 1961), we expected higher mortality for larger adult fish than for smaller subadults at Heenan Lake. Heenan Lake cutthroat reach sexual maturity at approximately 350 mm FL (Eric Gerstung, California Department of Fish and Game, pers. commun.). However, mortality for small fish (66%) was higher than for intermediate (53%) or large fish (41%) (Table 3); these differences were not significant ($X^2 = 2.55$, 2 df, $p > .05$). Klein (1966) and Warner (1978) also showed no significant differences in hooking mortality between different sizes and ages of salmonids. Marnell and Hunsaker (1970) found no mortality difference between hooked spawning and non-spawning cutthroat trout.

TABLE 3. Mortality of Lure-Caught Lahontan Cutthroat Trout, by Size Group, During July 29–31, 1983.

Size Group (Fork length range, mm)	*No. caught*	*No. (%) mortalities*
Small (200–299 mm)	29	16(55.2)
Intermediate (300–399 mm)	74	39(52.7)
Large (400–499 mm)	66	27(40.9)
Total (200–499 mm)	169	82(48.5)

Anatomical Site of Hooking

Wydoski (1977) suggested that single hooks caused greater mortality because they were swallowed more deeply than treble hooks. In this study, 87% of the trout caught were jaw-hooked. A total of 93% of the fish caught by single barbless hooks were jaw-hooked; thus, deep-hooking could not account for the higher mortality rates of these trout. Stringer (1967), Warner (1978), and Dotson (1982) reported that salmonids caught on artificial lures and flies were most frequently hooked in the jaws and mouth.

CONCLUSIONS

Significant hooking mortality of Lahontan cutthroat trout occurred only during the summer when the maximum water temperature was 21° C. Fish caught by single barbless hooks had the highest mortality rate (59%), followed by treble barbed (48%) and treble barbless (35%). Thus, the use of the "single barbless hook only" regulation to reduce hooking mortality is not supported by this study. We were unable to assess the effect of the anatomical hooking site since nearly all fish caught were hooked in the jaw.

We cannot rule out the possibility that handling and confinement at high temperatures, in addition to hooking stress, contributed to the high mortality in July. However, until further studies are conducted comparing mortality of fish that have been hooked and played against a control group that have not been stressed by hooking and held under confined conditions, we recommend against a summer catch-and-release fishery at Heenan Lake.

ACKNOWLEDGMENTS

We wish to express our appreciation to the many individuals who provided assistance in this study, especially with the field data collection. Special thanks to J. Deinstadt, California Department of Fish and Game, who proposed this study; to R. Wickwire, California Department of Fish and Game, and E. Davis, Alpine County Fish and Game Commission, for invaluable assistance in the field; to R. Carpenter and H. Mosegaard, for consultation regarding statistical treatment of the data; and to the California Conservation Corps, for construction of live boxes.

LITERATURE CITED

Ball, O. P., and O. B. Cope. 1961. Mortality studies on cutthroat trout in Yellowstone Lake. U.S. Fish Wildl. Serv., Res. Rept. No. 55. 76p.

Benson, N. G., and R. V. Bulkley. 1963. Equilibrium yield and management of cutthroat trout in Yellowstone Lake. U.S. Fish Wildl. Serv., Res. Rept. No. 62. 44p.

Bjornn, T. C. 1975. The St. Joe River cutthroat fishery—a case history of angler preference. Ann. Conf. West. Assoc. State Game Fish Comm., Proc. 55:187–194.

Calhoun, A. J. 1942. The biology of the black-spotted trout (*Salmo clarki henshawi* Gill and Jordan) in two Sierra lakes. PhD Thesis, Stanford University. 218p.Dotson, T. 1982. Mortalities in trout caused by gear type and angler-induced stress. Nor. Am. J. Fish. Man., 2:60–65.

Dwyer, W. P., and R. H. Kramer. 1975. The influence of temperature on scope for activity in cutthroat trout. *Salmo clarki*. Am. Fish. Soc., Trans., 104(3):552–554.

Falk, M. R., D. V. Gilman, and L. W. Dahlke. 1974. Comparison of mortality between barbed and barbless hooked lake trout. Environment Canada, Fisheries and Marine Service, Resource Management Branch, Technical Report Series No. CEN/T-74-1. 28p.

Hunsaker, D., L. F. Marnell, and F. P. Sharpe. 1970. Hooking mortality of Yellowstone cutthroat trout. Prog. Fish Cult., 32(4):231–235.

Klein, W. D. 1965. Mortality of rainbow trout caught on single and treble hooks and released. Prog. Fish Cult., 27(3):171–172.

________.1966. Mortality of trout caught on artificial lures and released by fishermen. Am. Fish. Soc., Trans., 95(3):326–328.

Marnell, L. F., and D. Hunsaker. 1970. Hooking mortality of lure-caught cutthroat trout (*Salmo clarki*) in relation to water temperature, fatigue, and reproductive maturity of released fish. Am. Fish. Soc., Trans., 99(4):684–688.

Snedecor, G. W., and W. G. Cochran. 1967. Statistical methods (Sixth Edition). Iowa State University Press, Ames, Iowa. 593p.

Stringer, G. E. 1967. Comparative hooking mortality using three types of terminal gear on rainbow trout from Pennask Lake, B.C. Can. Fish-Cult., 39:17–21.

Vigg, S. C., and D. L. Koch. 1980. Upper Lethal temperature range of Lahontan cutthroat trout in waters of different ionic concentration. Am. Fish. Soc., Trans., 109:336–339.

Warner, K. 1976. Hooking mortality of landlocked Atlantic salmon, *Salmo salar*, in a hatchery environment. Am. Fish. Soc., Trans., 105(3):365–369.

________. 1978. Hooking mortality of lake-dwelling landlocked Atlantic salmon, *Salmo salar*. Am. Fish. Soc., Trans., 107(4):518–522.

________. 1979. Mortality of landlocked Atlantic salmon hooked on four types of fishing gear at the hatchery. Prog. Fish Cult., 41(2):99–102.

Wydoski, R. S. 1977. Relation of hooking mortality and sublethal hooking stress to quality fishery management. Pages 43–87 *in* R. A. Barnhart and T. D. Roelofs, eds. Catch-and-release fishing as a management tool, a national sport fishing symposium. Humboldt State Univ., Calif. Coop. Fish. Unit and Cal. Trout, Inc. 220p.

Calif. Fish and Game 74(4): 226–231 1988

WATERFOWL MORTALITY IN RICE FIELDS TREATED WITH THE CARBAMATE, CARBOFURAN [1]

E. E. LITTRELL
California Department of Fish and Game
Environmental Services Division
1701 Nimbus Road, Suite F
Rancho Cordova, California 95670

A series of losses of waterfowl and raptors in the rice fields of California's Sacramento Valley was caused by carbofuran intoxication. Carbofuran residues of up to 640 ppm (wet weight) were detected in gizzard and crop contents of dead birds. Brain cholinesterase levels were depressed up to 86 percent. Two incidents of secondary intoxication were found in raptors which fed on poisoned ducks. Additional raptors were found dead or ill in similar circumstances. These losses took place under both normal agricultural practices and possible misuse conditions. Recommendations for changes in application procedures to protect waterfowl are presented.

INTRODUCTION

A series of waterfowl losses occurred in the Sacramento Valley of California in the years 1984 to 1988. Approximately 525 birds were reported killed in 22 incidents. Springtime losses all occurred in rice fields treated immediately prior with the carbamate insecticide, carbofuran (Furadan 5G®, FMC Corp. or Furadan 5% Granular®, Mobay Chemical Corp.). Birds found in the fall and winter contained carbofuran. This report documents the process of analyzing this problem and developing a resolution.

The use of carbofuran has recently increased because of the withdrawal of the carbamate insecticide Bux 10G® (bufencarb). Carbofuran use in rice has increased from 15,128 ha (37,352 ac) treated in 1978 to 39,378 ha (97,304 ac) in 1985. Bufencarb use has dropped from 56,615 ha (139,792 ac) treated in 1978 to 61 ha (150 ac) in 1985 (Unpublished Annual California Department of Food and Agriculture Pesticide Use Reports).

MATERIALS AND METHODS

Loss Reports

Losses were reported to the California Department of Fish and Game (CDFG) by farmers, pest control advisors, and personnel from County Agricultural Commissioners (CAC), California Department of Food and Agriculture (CDFA) and pesticide companies. The first loss was reported to the Pesticide Investigations Unit of the CDFG Environmental Services Division in May of 1984. A pest control advisor reported finding 50 dead ducks, mainly Mallard, *Anas platyrhynchos,* and teal, *Anas* spp., two days after application of carbofuran to a field in Colusa County. Subsequent to this report, two other losses were reported. A loss of five Mallards occurred in a drainage ditch adjacent to the Gray Lodge State Wildlife Area in Butte County. Four ducks

---

[1] Accepted for publication July 1988.

(two Mallards, a Cinnamon Teal, *A. cyanoptera,* and a Blue-winged Teal, *A. discors*), were found in Colusa County.

In the spring of 1985 the CDFG, CDFA, and the CAC made an effort to look for wildlife losses. Five losses totaling 31 ducks were reported, all in Colusa and Glenn Counties. Individual reported losses ranged from four to 19 Mallards.

In the fall of 1985, three incidents were reported to the DFG and two to the U.S. Fish and Wildlife Service (USFWS). Approximately 203 ducks were killed. The majority were Mallards but also included American Wigeon, *A. americana,* Northern Shoveler, *A. clypeata,* Gadwall, *A. strepera,* Northern Pintail, *A. acuta,* and Green-winged Teal, *A. crecca.* Also reported in these losses were five American Coots, *Fulica americana,* a Snow Goose, *Chen caerulescens,* and a Northern Harrier, *Circus cyaneus.*

Six loss incidents took place in rice fields during the spring of 1986. These losses included nine Mallard, two Cinnamon Teal, and one shorebird. There were unverified reports of other losses occurring and of additional dead ducks being associated with those submitted for analysis.

Two incidents were reported in the fall of 1986. Approximately 160 ducks and four Red-tailed Hawks, *Buteo jamaicensis,* were involved in an incident in Glenn County. Fifty-eight ducks were found dead in Colusa County. Species composition was similar to previous episodes.

Three Mallards from two locations were the only ducks found in the spring of 1987. Approximately 50 dead ducks were found in January 1988. No dead ducks were found in the spring of 1988. Aerial surveillance, in addition to ground searches, were conducted in the spring of 1987 and 1988.

Sample Analysis

Birds were frozen as soon as possible after collection. Detailed necropsies were conducted in some cases by the CDFG; in others, only a general external examination was made. Detailed necropsies included fluoroscopy, examination for trauma, and bacterial culture for avian cholera and botulism. Brains were excised from some birds found in the spring and fall of 1985 and the fall of 1986. Cholinesterase level determinations were made primarily at the Avian Science Department, University of California at Davis. Hunter-shot birds were used for determining brain cholinesterase control values.

Brain cholinesterase levels were determined by the Hill and Fleming (1982) adaptation of the Ellman assay (1961). Brain homogenates were assayed in the presence of 2.5×10^{-4} M DTNB (5,5′-dithiobis (2-nitrobenzoic acid)) and 5.0×10^{-4} M acetylthiocholine iodide in a phosphate buffer (pH 7.4, 0.05 M). Values are reported as uMoles acetylthiocholine hydrolyzed per minute per gram of brain tissue (uM/min/g).

Gizzard contents ($N=42$) were analyzed for carbofuran residues at the CDFG Fish and Wildlife Water Pollution Control Laboratory.

Gizzard contents of the bird samples were blended with 300 ml of 0.25 N hydrochloric acid. The homogenate was vacuum filtered through a Buchner funnel with Watman® #42 filter paper. A 30 ml aliquot of the filtrate was extracted with 60 ml of petroleum ether four times. A few drops of aqueous solution of sodium lauryl sulfate was used to break up any emulsions. Twenty-five ml of diethyl ether were added to the combined petroleum ether extract and then passed through a layer of anhydrous sodium sulfate. The extract was concentrated to 5 ml in 500 ml Kuderna-Danish evaporator and Snyder column. The extract was checked for carbofuran on a gas chromatograph equipped with a nitrogen-specific detector and a 3 ft column packed with 6 percent OV-1. The detection limit for a 10-g sample was 1 ppm, wet weight.

RESULTS

The most consistent clinical sign in necropsied birds was the prolapsed penis of the male ducks. This sign has been seen by us in ducks intoxicated by the carbamate and organophosphate insecticides carbofuran and diazinon. The only disease known to produce this sign is duck viral enteritis (Wobeser 1981). The birds examined in the spring of 1984 and in January, 1988 by a wildlife pathologist of the CDFG showed no signs of disease (Unpublished CDFG Wildlife Investigations Laboratory reports N-38-84 and N-4-84, and N-4-88). All 30 ducks examined were in good body condition. No gross lesions were noted in thoracic or abdominal viscera. Blood smears were negative for bipolar rods of avian cholera. Fluoroscopy revealed no shot. The mouse cross-protection test for botulism was negative.

In the spring and fall of 1985 and 1986 and in the spring of 1987, having seen a clear probability of carbofuran intoxication in submitted birds, no detailed disease examinations were conducted. The prolapsed penis was again seen on some male ducks. A superficial examination of birds submitted demonstrated the ducks, coots and hawks were fat, indicative of good health, and did not show obvious signs of disease or trauma.

Carbofuran residues were detected in most samples examined. Concentrations of carbofuran detected in waterfowl ranged from undetected to 640 parts per million (ppm) (Table 1). Carbofuran was also recovered from the crop contents of two raptors. A Northern Harrier found ill in the fall of 1985 and subsequently euthanized contained 64 ppm carbofuran in its crop contents. A Red-tailed Hawk found dead in the fall of 1986 contained 59 ppm carbofuran in its crop contents. Crop contents of both birds consisted of animal digestive tract fragments and feathers. In the Red-tailed Hawk, duck gizzard wall tissue was present, confirming the consumption of waterfowl and consequent secondary poisoning in these hawks. Other hawks were found in association with the dead ducks, but were too decayed for analyses.

TABLE 1. Carbofuran Residues (ppm wet weight) Found in Birds in Rice Fields, 1984–1988.

Accession	*Year*	*Species*	*Residue (ppm wet wt.)*
769-1	1984 Spring	Mallard	3.7
769-2	1984 Spring	Mallard	11
769-3	1984 Spring	Mallard	28
772-1	1984 Spring	N.S.[a]	2.3
772-2	1984 Spring	N.S.[a]	68
772-3	1984 Spring	N.S.[a]	37
772-4	1984 Spring	N.S.[a]	<0.3[b]
783-1	1984 Spring	Gadwall	82
874-1	1985 Spring	Mallard	3.6
874-2	1985 Spring	Mallard	6.3
875-1	1985 Spring	Mallard	9.3
875-2	1985 Spring	Mallard	10
876-1	1985 Spring	N.S.	14
876-2	1985 Spring	N.S.	1.6
888 (male)	1985 Spring	Mallard	9

888 (female)	1985 Spring	Mallard	1.2
944	1985 Fall	Composite [c]	41
944	1985 Fall	American Coot	310
944	1985 Fall	Harrier	64
949	1985 Fall	Mallard	37
950	1985 Fall	Mallard	23
975	1986 Spring	Mallard	4.2
977-1	1986 Spring	Mallard	<0.3 [b]
977-2	1986 Spring	Mallard	<0.3 [b]
977-3	1986 Spring	Mallard	<0.3 [b]
977-4	1986 Spring	Mallard	0.7
986	1986 Spring	Cinnamon Teal	0.9
987	1986 Spring	Mallard	<0.3 [b]
1025	1986 Spring	Cinnamon Teal	30
1031	1986 Spring	Mallard	6
1045 (male)	1986 Fall	Mallard	64
1045 (female)	1986 Fall	Mallard	4.6
1045 (male)	1986 Fall	Wigeon	640
1045 (female)	1986 Fall	Wigeon	40
1045 (male)	1986 Fall	Northern Pintail	0.8
1045 (female)	1986 Fall	Northern Pintail	<1
1045 (composite [2])	1986 Fall	Mallard	220
1045 (composite [2])	1986 Fall	Mallard	33.7
1047 (male)	1987 Spring	Mallard	3.8
1047 (male)	1987 Spring	Mallard	1.8
1047 (male)	1987 Spring	Mallard	3.7
1105	1988 Winter	Composite [c]	6.4

---

[a] Not specified.

[b] Not detected at sensitivity noted.

[c] Wigeon, Mallard, Pintail.

Birds from the spring and fall of 1985 and the fall of 1986 were tested for brain cholinesterase activity. Birds from the spring of 1985 did not show a depression. Since carbofuran residues were detected in dead ducks, the cholinesterase probably spontaneously reversed (Hill and Fleming 1982). Cholinesterase activity levels in birds from the fall of 1985 and 1986 were greatly depressed (Tables 2 and 3). The Red-tailed Hawk also had a spontaneously reversible depression. An initial activity level of 8.45 uM/min/g spontaneously reversed in the laboratory analysis to 13.97 uM/min/g indicating an exposure to a readily reversible material like a carbamate.

TABLE 2. Brain Cholinesterase Levels in Control and Carbofuran Exposed Waterfowl, Fall 1985.

Species	*Sex*	*Control (N)* *(C)*	*Exposed (N)* *(E)*	*% Depression* *(1 − E/C = %)*
Mallard	Male	12.4 ± 2.4 (5)	2.7 ± 1.5 (3)	78%
	Female	10.7 (2)	5.2 ± 2.1 (3)	51%
American Coot	mixed	21.1 ± 5.1 (8)	4.2 ± 1.84 (5)	80%

---

[a] Cholinesterase activities in uMoles acetylthiocholine hydrolyzed/min/gram of brain tissue represent the mean and standard deviation of N samples.

TABLE 3. Brain Cholinesterase Levels in Control and Carbofuran Exposed Waterfowl, Fall 1986.

Species	*Sex*	*Control (N)* *(C)*	*Exposed (N)* *(E)*	*% Depression* *(1 − E/C = %)*
Mallard	Male	12.01 ± 0.65 (4)	1.90 ± 0.15 (3)	86%
	Female	12.89 ± 0.94 (5)	3.22 (2)	75%

---

[a] Cholinesterase activities in uMoles acetylthiocholines hydrolyzed/min/gram of brain tissue represent the meanand standard deviation of N samples.

DISCUSSION

The reported loss of ducks over a period of five years (1984–1988) has been well documented. Both recovery of carbofuran at toxic levels (Hudson, Tucker and Haegele 1984) in most birds and severe depression of brain cholinesterase in the birds from the fall of 1985 and 1986 point to carbofuran intoxication as the cause of death. The apparent mode of exposure is through ingestion of granules of formulated carbofuran. Granules were seen by county personnel in a duck's gizzard in the fall of 1986. Carbofuran is very toxic to waterfowl, having laboratory acute oral LD 50 values of 0.23 mg/kg in female Fulvous Whistling-Ducks, *Dendrocygna bicolor,* and 0.480 and 0.510 mg/kg in male and female Mallards, respectively.

A 50 percent brain cholinesterase depression in dead birds is indicative of an anti-cholinesterase agent (e.g., a carbamate) causing death (Hill and Fleming 1982). The lack of a 50 percent depression in the spring 1985 birds is not unexpected. Carbamate-induced inhibition is readily reversible, especially in this kind of incident where animals may be found in the field after lying for several days.

In the spring, carbofuran is applied by either air or ground equipment to prepared rice fields at the rate of 22 kg/ha (20 lb/ac) of product, or 1.1 kg active ingredient per ha (1 lb/ac) for control of rice water weevil. The field is then flooded, and soaked rice seed is applied by air. Apparently waterfowl, primarily Mallards, ingest the granules directly as if they were seed or grit. Mallards are the primary nesting birds in the region. The hazard appears to be greatest in the first one of two rice fields being flooded. Most dead birds have been found there. Mallards prefer to forage in freshly flooded fields.

The source of the carbofuran causing the losses of birds in the fall and winter could not be determined. Waterfowl, of various dabbling species plus American Coots, again died from direct ingestion of granules. Red-tailed Hawks apparently were killed secondarily from scavenging and the Northern Harrier was severely intoxicated by a secondary exposure. Birds fed upon dead ducks. Examined birds had 59 to 64 ppm carbofuran in their crop contents of feathers and animal digestive tract. Carbofuran formulations are not registered for use on any rice pest in the fall or winter. The lack of persistence of carbofuran has been well documented (Siddaramappa et al. 1978, Siddaramappa and Seiber 1979, Isensee and Tayaputch 1986, Rajagopal, Panda, and Sethunathan 1986). The literature does not support the hypothesis that carbofuran persisted in rice fields for up to eight months from legal spring applications.

Two papers by Flickenger et al. (1980, 1986) report finding Furadan 3G® granules in birds found dead in rice fields in Texas. Balcomb et al. (1984) reported birds killed by Furadan 10G® granules applied to soil for corn rootworm control. A synoptic review of carbofuran's hazards has been made by Eisler (1985).

Work continues to eliminate the deleterious effects of carbofuran. Cultural methods involving incorporation of granules into the soil prior to flooding has shown great promise with respect to lowering or eliminating the incidents of waterfowl loss. Use or modification of this application practice or development of other methods to prevent losses will continue until there is assurance that no waterfowl will be lost as a result of normal rice cultural practices using carbofuran. Enforcement activities will continue as a measure to prevent the possible illegal use of carbofuran during the fall months.

ACKNOWLEDGMENTS

Chemical analyses were performed by T. Lew, pesticide chemist at the CDFG Fish and Wildlife Water Pollution Control Laboratory. Most cholinesterase analyses were made by M. Hooper, Avian Sciences Department, University of California at Davis.

LITERATURE CITED

Balcomb, R., C.A. Bowen, D. Wright, and M. Law. 1984. Effects on Wildlife of At-planting Corn Applications of Granular Carbofuran. J. Wildl. Manage., 48(4):1353–1359.

Eisler, R. 1985. Carbofuran Hazards to Fish, Wildlife and Invertebrates: A Synoptic Review. USFWS Biol. Rep. 85(1.3). 36 pp.

Ellman, G. L., R. D. Courtney, V. Andus, and R. M. Featherstone. 1961. A New and Rapid Colorimetric Determination of Acetylcholinesterase Activity. Biochem. Pharm., 7:88–95.

Flickenger, E. L., K. A. King, W. F. Stout, and M. M. Mohn. 1980. Wildlife Hazards from Furadan 3G Applications to Rice in Texas. J. Wildl. Manage., 44(1):190–197.

Flickenger, E. L., C. A. Mitchell, D. H. White, and E. J. Kolbe. 1986. Bird Poisoning from Misuse of Carbamate Furadan in Texas Rice Field. Wildl. Soc. Bull., 14:59–62.

Hill, E. F. and W. J. Fleming. 1982. Anticholinesterase Poisoning of Birds: Field Monitoring and Diagnosis of Acute Poisoning. Environ. Tox. and Chem. 1:27–38.

Hudson, R. H., R. K. Tucker, and M. A. Haegele. 1984. Handbook of Toxicity of Pesticides to Wildlife. USFWS Resource Publication No. 153. Washington, D. C.

Isensee, A. R. and N. Tayaputch. 1986. Distribution of Carbofuran in a Rice-Paddy-Fish Microecosystem. Bull. Environ. Contam. Tox., 36(6): 763–769.

Rajagopal, B. S., S. Panda, and N. Sethunathan. 1986. Accelerated Degradation of Carbaryl and Carbofuran in a Flooded Soil Pretreaded with Hydrolysis Products, 1-Naphthol and Carbofuran Phenol. Bull. Environ. Contam. Tox., 36:827–832.

Siddaramappa, R., A. C. Tirol, J. N. Seiber, E. A. Henrichs, and I. Watanabe. 1978. The degradation of Carbofuran in Paddy Water and Flooded Soil of Untreated and Retreated Rice Fields. J. Environ. Sci. Health. B13(4):369–380.

Siddaramappa, R. and J. N. Seiber. 1979. Persistence of Carbofuran in Flooded Rice Soils and Water. Prog. Wat. Tech., 11(6):103–111.

Wobeser, G. A. 1981. Diseases of Wild Waterfowl. Plenum Press. New York and London.

Calif. Fish and Game 74(4): 232–235 1988

SALINITY TOLERANCE OF YOUNG TOPSMELT, *ATHERINOPS AFFINIS,* CULTURED IN THE LABORATORY [1]

DOUGLAS P. MIDDAUGH
U.S. Environmental Protection Agency
Sabine Island, Gulf Breeze, FL 32561

and

JONATHAN M. SHENKER
University of California, Davis
Bodega Marine Laboratory
Bodega Bay, CA 94923

Topsmelt, *Antherinops affinis,* were cultured at 21 ± 1° C and salinities of 10‰ and 30‰ from the day of hatching to 24 days old. Thereafter, the salinity was lowered 2‰ per day for the group originally maintained at 10‰ and raised 2‰ per day for the group cultured at 30‰ salinity. Observations for mortality were made daily throughout the study. No fish died at 10‰ salinity during the first 24 days after hatching and no mortalities occurred as salinity was lowered from 10‰ to 2‰, or during the subsequent 29-day holding period at 2‰. One fish died in the group at 30‰ during the 24-day period after hatching. As salinity was increased by 2‰ daily, no deaths occurred until day 40 at 60‰ salinity. Thereafter, cumulative mortality increased to 48% at a salinity of 80‰. At 82‰ salinity, mortality totalled 80%.

INTRODUCTION

The topsmelt, *Atherinops affinis,* ranges from the Gulf of California to near Sooke Harbor, British Columbia (Miller and Lea 1972). In California, it lives in fresh and brackish water and at salt concentrations considerably higher than the ocean. Field observations revealed that adults may spawn at a salinity of 72‰, more than twice that of ocean water (Carpelan 1957). It has been reported that salinity in the Alviso Salt Ponds in upper San Francisco Bay became intolerable for young *topsmelt* between 80 and 90‰ (Carpelan 1955). This study was conducted to determine the upper and lower salinity tolerance of juvenile *topsmelt* from Estero Americano near Bodega Bay, California (lat 38° 31′ 08″ N, long 123° 08′ 04″ W).

MATERIALS AND METHODS

Eggs and sperm were stripped from adults collected in early July 1987 at 34‰ salinity and 17° C. Hydrated eggs from two females were stripped into a 20 cm diameter glass culture dish containing ambient seawater; then sperm from two males was stripped into a second dish, mixed well, and immediately poured into the dish containing eggs. After 15 minutes, the resulting embryos were washed 3 times with ambient seawater. The embryos, which have chorionic filaments that bind them together into long strands, were then wrapped (in a diagonal pattern) around stainless steel screens, each 12 cm x 3 cm x 8 mm mesh, to form a helical-like configuration of ∼ 800 embryos that was never more than 3 embryos thick. Each screen was then placed in a 500 ml wide-mouth plastic vacuum bottle filled with ambient salinity seawater. Each

---

[1] Accepted for publication July 1988. Contribution No. 626 of the Gulf Breeze Environmental Research Laboratory.

bottle was aerated with pure oxygen for 30 seconds, sealed and shipped via air-express to the Gulf Breeze Environmental Research Laboratory in Florida. Upon arrival in Florida, fertilized eggs were held at 30‰ and 21 ± 1° C for 14 days, when hatching occurred. Six to 10 newly-hatched larvae were weighted and measured, mean standard length (SL) at hatching was 5.2 mm and wet weight 0.0011 g. Newly hatched larvae were maintained in two 20 *l* glass aquaria containing 18 *l* of seawater at either 10‰ or 30‰ salinity and 21 ± 1° C. Ninety larvae (5 larvae/*l*) were stocked in each aquarium. Larvae held at 10‰ were acclimated to this salinity during an 8 hour period. Larval *Atherinops* were fed 5000 newly hatched *Artemia* nauplii/*l* daily. Nauplii were washed with deionized water before being added to each aquarium.

On alternate days, throughout the study, ~ 20% of the water in respective aquaria was changed with salinity and temperature adjusted water. Salinities were held constant at 10‰ and 30‰ for 24 days posthatch. Because of rapid growth, the population in each tank was reduced to 50 fish on the 24th day posthatch. At this time, fish at 10‰ had a $\bar{X}$ SL of 14.7 mm and wet weight of 0.321 g; at 30‰ $\bar{X}$ SL was 15.0 mm and weight 0.382 g. Thereafter the salinity was lowered 2‰ per day for the group originally maintained at 10‰ and raised 2‰ per day for the group cultured at 30‰ salinity. Observations for mortality were made daily throughout the study.

Periodic measurements of pH (Orion Model SA 520 meter)[2] and dissolved oxygen, D.O., (Lazar Model DO 166 oxygen probe) were made as salinities were decreased or increased. An American Optical refractometer, readable to 0.5‰ was used to measure salinity. Deionized water was used to lower salinity. A brine solution (150‰) prepared from Instant Ocean® sea salts was used to increase salinity.

RESULTS AND DISCUSSION

No fish died at 10‰ during the first 24 days after hatching (Fig. 1A), and no mortalities occurred as salinity was lowered from 10‰ to 2‰ or during the subsequent 29-day holding period at 2‰ salinity (Fig. 1A).

Only one death occurred at 30‰ during the 24-day interval after hatching. No additional deaths were observed until day 40, at a salinity of 60‰ (Fig. 1B). Thereafter, cumulative mortality increased from 4 to 48% as salinity increased to 80‰. At salinities of > 60‰ survivors exhibited a decrease in body volume (fluids) due to osmotic stress. Twenty-four hours after increasing the salinity to 82‰, the cumulative mortality rose to 80%. The survivors, obviously under extreme osmotic stress and swimming in a disoriented manner, were preserved. Fish maintained at 2‰ were also preserved.

Based on the measured values for pH and D.O. (Table 1) it seems that these variables could have played a role in salinity tolerance of *Atherinops affinis*. Carpelan (1961) suggested that decreases in oxygen solubility, at elevated salinities in Los Penasquitas Lagoon, could have interacted with osmotic stress in the elimination of organisms from the lagoon.

---

[2] Mention of trade names does not imply endorsement by the U.S. Environmental Protection Agency.

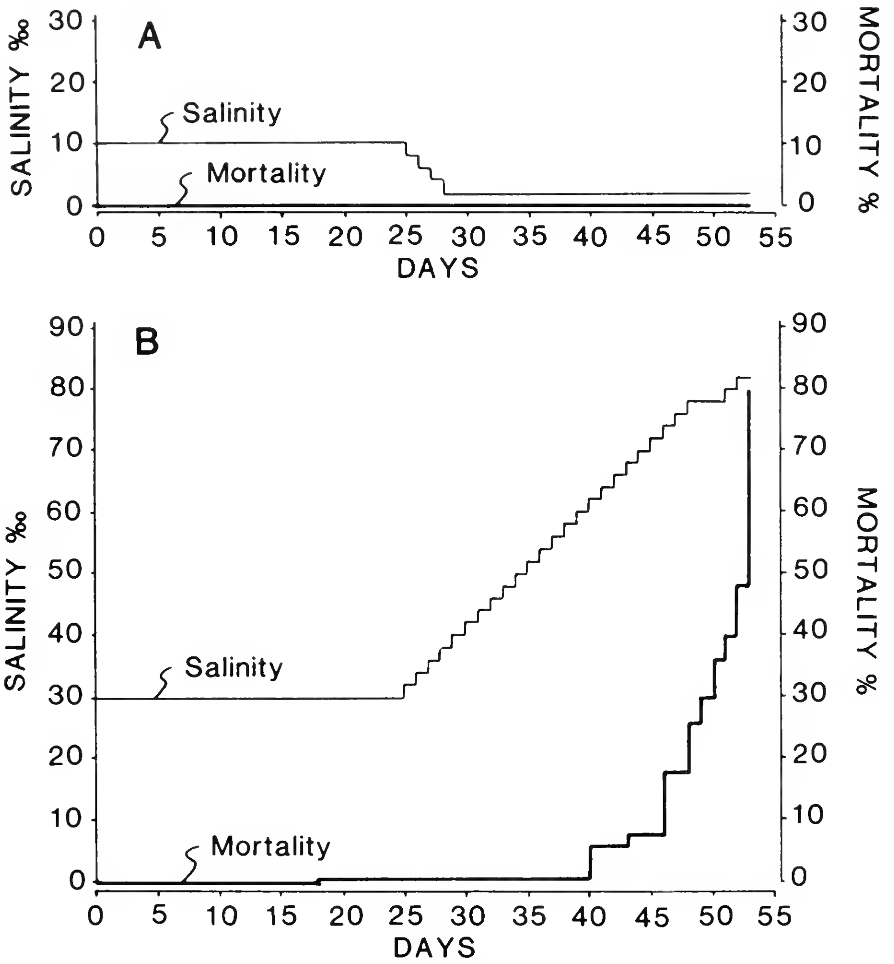

FIGURE 1. A- Incremental 2°/oo decreases in salinity and concurrent cumulative mortality for young *A. affinis,* B- Incremental 2°/oo Increases in salinity and concurrent cumulative mortality.

TABLE 1. Salinity, Dissolved Oxygen and pH Values in Aquaria Used to Culture Topsmelt, *Atherinops affinis.*

Salinity °/oo	*Dissolved Oxygen* mg/l	*pH* units
2	8.5	7.2
10	8.1	7.5
20	6.8	7.8
30	7.6	8.2
40	7.3	8.3
60	6.0	8.3
80	5.8	8.3

Growth in SL and wet weight during the salinity tolerance tests was significantly greater (t-test, $\alpha = 0.05$) for the group held at 10°/oo to 2°/oo (final $\bar{X}$ SL 25.0 mm, wet weight 0.1569 g) than for individuals cultured at 30°/oo to 82°/oo (final $\bar{X}$ SL 22.3 mm, wet weight 0.0942 g).

In summary, our results indicate that juvenile *Atherinops affinis* from Estero Americano can tolerate salinities ranging from 2°/oo to approximately 80°/oo. However, growth was severely impeded in hypersaline waters. Carpelan (1955) observed that while *Atherinops* did not mature at high salinities, adults were capable of spawning at 72°/oo. They produced viable eggs and young fish that survived until a salinity of 90°/oo was reached in the Alviso Salt Ponds. Death of juvenile *Atherinops* in the present study at 80–82°/oo salinity may have occurred because parental fish in Estero Americano were collected at a salinity of 34°/oo. Juveniles from this parental stock may be less tolerant of high salinity than juvenile progeny of adults residing in the Alviso Salt Ponds where hypersaline conditions are present. Nevertheless, our results are in general agreement with the observations of Carpelan (1955) for juvenile *Atherinops* residing in the Alviso Salt Ponds.

As salinity increased during summer and early fall in the Los Penasquitas Lagoon, California (lat 32° 55′ 00″ N, long 117° 15′ 40″W), Carpelan (1961) noted that *Atherinops affinis littoralis* thrived at the maximum salinity of 63°/oo. In the Laguna Madre, Texas, another atherinid the inland silverside *Menidia beryllina,* has been found at a salinity of 75°/oo and was reported as numerous at 45°/oo (Simmons 1957).

In a study conducted with larval and juvenile *A. affinis* and *Atherinopsis californiensis,* it was demonstrated that the former showed optimal survival and growth at 30°/oo salinity while the latter had best survival and growth at salinities of 10 or 20°/oo (Middaugh et al. in preparation). These observations suggest that *A. affinis* is better suited to hypersaline habitats than *A. californiensis,* a trend that seems to confirm the observations of Carpelan (1957) for the Alviso Salt Ponds and Carpelan (1961) in a survey of fishes from the hypersaline Los Penasquitas Lagoon. In both habitats, *A. affinis* was present at salinities of ~ 65 to 85°/oo. No *A. californiensis* were collected.

The range of salinity tolerance demonstrated by young *A. affinis* that reside in lagoon, estuarine and neritic waters along the Pacific coast suggests that this species may be useful in conducting toxicological research at a wide range of salinities. The euryhaline nature of this fish indicates that it could be used in tests with freshwater effluents entering marine habitats, where the salinity of receiving waters is measurably diluted; or in semi-enclosed areas such as lagoons where hypersaline conditions might occur during periods of high temperature and low rainfall.

LITERATURE CITED

Carpelan, L.H. 1955. Tolerance of the San Francisco topsmelt, *Atherinops affinis,* to conditions in salt-producing ponds bordering San Francisco Bay. Calif. Fish and Game, 41(4):279–284.

________. 1957. Hydrobiology of the Alviso Salt Ponds. Ecology, 38(3):375–390.

________. 1961. Salinity tolerances of some fishes of a southern California coastal lagoon. Copeia, 1961(1):32–39.

Miller, D.J., and R.N. Lea. 1972. Guide to the coastal marine fishes of California. California Department of Fish and Game. Fish Bulletin 157, 235 p.

Middaugh, D.P. et al. Laboratory culture of embryonic and larval jacksmelt, *Atherinopsis californiensis,* and topsmelt, *Atherinops affinis,* with notes on identification of each species. In preparation.

Simmons, E.R. 1957. Ecological survey of the upper Laguna Madre of Texas. Publ. Inst. Mar. Sci. 4(2):156–200.

Calif. Fish and Game 74(4): 236–248 1988

NOTES

REOCCURRENCE OF THE PACIFIC SEAHORSE, *HIPPOCAMPUS INGENS,* IN SAN DIEGO BAY

The Pacific seahorse, *Hippocampus ingens*, has reappeared in San Diego Bay. *Hippocampus ingens* is the only species of seahorse in the eastern Pacific and is one of the largest seahorses known, reaching a maximum length of 12 in. (30 cm) (Miller and Lea 1972). The normal distributional range of the Pacific seahorse is from central Baja California to northern Peru (Hubbs and Hinton 1963). Although common, especially in bays over this geographic area, it has rarely been reported in California waters (Starks and Morris 1907, Hubbs and Hinton 1963, Miller and Lea 1972, Eschmeyer and Herald 1983). There have been only nine specimens reported from the San Diego area since the mid 1800's (five in 1857, one in 1872, one in 1880, one in 1962, and one in 1958 or 1959) (Hubbs and Hinton 1963). A survey of San Diego Bay eelgrass beds in 1980–81 did not reveal any seahorses (Hoffman 1986). Reported here, are additional records collected recently from San Diego Bay and adjacent waters documenting the return of *Hippocampus ingens* to the San Diego Bay area.

Since 1984, there has been an apparent resurgence of seahorses in San Diego Bay as accounted for by fishermen and divers. Twenty-two records have been tabulated (Table 1). The first of these seahorses was collected on 16 August 1984, by Jason Campbell while playing in the surf at Mission Beach. It was donated the same day to the Scripps Aquarium. In November 1984, while otter trawling immediately south of Coronado Cays at a depth of 4 m, we (ATJ and PD) collected a second seahorse. Six months later (3 May 1985), a specimen was taken in Mission Bay by a diver under his boat at Marina Village near the ocean channel. At this time, a report was received at Scripps Aquarium of a dead seahorse on a beach in Mission Bay. The next specimen was caught a month later when a seahorse wrapped its tail around the finger of a diver working in zero visibility at one of the Naval docks in San Diego Bay. The specimen was later donated to the Scripps Aquarium. In addition to the specimens which have been taken and donated to either the Scripps Aquarium or Sea World, there have been several reports from San Diego Bay of up to three individuals seen at one time (by a diver working under the radar dome of a U.S. Navy Destroyer at NASSCO Shipyard, and also by Navy Seal divers). Photographs of specimens taken in the Bay have been displayed at some of the local fishing piers.

TABLE 1. Records of *Hippocampus ingens* in San Diego Bay and Adjacent Areas.

Date	*No. Specimens*	*Length (cm)*	*Location*
16 Aug 1984	1	19.0	Mission Beach[a]
14 Nov 1984	1		So. of Coronado Cays
Mar 1985	2	24.5	E. Glorieta School, Coronado
3 May 1985	1		Marina Village "A" Dock
21 May 1985	1		Intercontinental Marina
8 Jun 1985	1	12.4	Glorietta Bay[b]

19 Jun 1985	1	20	Pier 4, San Diego Harbor
11 Aug 1985	1	16.3	J Street Pier, Chula Vista [c]
25 Mar 1986	1		Mission Bay [d]
25 Mar 1986	1	21.2	Pier 13, Naval Station [e]
21 May 1986	1		Chula Vista Pier
12 Jun 1986	1	21	E. Harbor Island Basin
14 Jun 1986	2	23, 24	Harbor Island Marina [f]
18 Jul 1986	1	20–25	National City
26 Aug 1986	1	24	Chula Vista Pier
17 Dec 1986	2	12.5, 20	Naval Amphibian Base
25 Feb 1987	2	15, 17.5	28th Street, Naval Pier
16 Oct 1987	1	16.2	32nd Street, Naval Pier [g]

---

[a] Washed up on beach, spent 3 months in aquarium, then died (SIO 84265).

[b] Specimen collected dead (SIO 85175).

[c] Caught in crab trap, water temperature (21.6° C).

[d] Specimen reported dead.

[e] Still alive at Scripps Aquarium, gave birth to 44 young (7 mm) in captivity. Water temperature (15–15.5° C), caught by Navy Seal divers.

[f] Pair observed mating in Sea World Aquarium 24 Jun. 1986 and young released on 16 Sept. 1986.

[g] Water temperature (22° C) (SIO 8893)

Most recently (12 June 1986) a specimen measuring 21 cm was found attached to eelgrass at a depth of about 2.5 m in east Harbor Island basin during a dive survey. Two specimens were also sighted by divers in eelgrass in San Diego Bay near Coronado Island (K. Dyke, pers. comm. 1985).

All the specimens from San Diego Bay were caught or observed in less than 10 m water depth and some seahorses were in areas near eelgrass habitat. Previous records indicate that the preferred habitat was offshore in open coastal water, where specimens were caught at depths greater than 10 m or were occasionally swimming at the surface (Fritzsche 1980).

At least two of these records were taken as male-female pairs. The size of seahorses reported here range from 15 cm to 25 cm.

Monthly trawling surveys of Mission Bay since April 1984 and weekly diving surveys over the same time period indicate no seahorses present even though eelgrass is plentiful (Kent and Ford, pers. comm.). A few seahorses have washed ashore, however, and have been collected alive (Snodgrass 1986).

Two events may account for the appearance of *Hippocampus* in San Diego Bay in recent years: a local warm water intrusion and changes in sewage disposal. The anomolous warming of local coastal water during the latest 'El Nino' event in 1982–83 (McGowan 1983) could have reestablished larvae or adults in San Diego Bay from the southern populations. The previous warming in southern California, 1957–1959, could account for the earlier mentioned 1958 and 1962 seahorse records (Hubbs and Hinton 1963). The fact that the first specimen in 1984 was found on an open ocean beach lends support to this hypothesis.

The health of the eelgrass habitat inside San Diego Bay has been improved by the elimination of direct sewage discharge and restrictions on other pollutants entering San Diego Bay within the last decade or so.

The potential for successful reproduction is plausible considering that two specimens caught near Harbor Island Marina subsequently released young in aquaria (C. Jantsch, pers. comm., 1986). The seahorses kept at the Scripps Aquarium also released young. A large female specimen which was donated to the Scripps Aquarium in July 1986, after five months in captivity, was gravid. Two pairs of smaller specimens currently residing at the Scripps Aquarium court frequently and remain as distinct pairs. The females are too small to produce many eggs, indicating that they are young individuals, possibly spawned in San Diego Bay.

It now remains to be seen whether the seahorse population will remain or if their appearance is only sporadic and associated with warm water events.

We acknowledge assistance from H.J. Walker, Scripps Fish Collection, C. Jantsch, aquarist at Sea World, R.F. Ford and anonymous reviewers.

LITERATURE CITED

Eschmeyer W.N. and E.S. Herald 1983. A field guide to Pacific Coast fishes of North America: from the Gulf of Alaska to Baja California. Houghton Mifflin, Boston. 336 p.

Fritzsche, R.A. 1980. Revision of the Eastern Pacific Syngnathidae (Pisces: Syngnathiformes), including both recent and fossil forms. Proc. Calif. Acad. Sci., 42:181–227.

Hoffman, R.S. 1986. Fishery utilization of eelgrass (*Zostera marina*) beds and non-vegetated shallow water areas in San Diego Bay. NMFS Adm. Rep., SWR-86-4. 29 p.

Hubbs, C.L. and S.D. Hinton 1963. The giant sea horse returns. Pac. Discovery, 16(5):12–15.

Kent, D. and R.F. Ford. in prep, Sea World Research Institute, Hubbs Marine Center Technical Report.

McGowan, J.A. 1983. The California El Nino, 1983. Oceanus, 27(2):48–51.

Miller, D.J. and R.N. Lea. 1972. Guide to the coastal marine fishes of California. Calif. Dept. Fish and Game, Fish Bull. 157:235 p.

Snodgrass, R.E. 1986. Of Sea Horses and Snipefish. Scripps Aquarium Newsletter, Winter 1986, p 3.

Starks, E.C. and E.L. Morris 1907. The marine fishes of Southern California.Univ. Calif. Publ. Zool., 3(11): 159–251.

—Anthony T. Jones, Hawaii Undersea Research Laboratory, 1000 Pope Rd., Honolulu, Hawaii 96822; Peter Dutton, Center for Marine Studies, San Diego State University, San Diego, CA 92182; and Robert E. Snodgrass, T. Wayland Vaughan Aquarium, Scripps Institution of Oceanography, La Jolla, CA 92093.

Accepted for publication April 1988.

PREVALENCE OF *TRICHOMONAS GALLINAE* IN CENTRAL CALIFORNIA MOURNING DOVES

Trichomonas gallinae is an important parasite of columbid birds. Serious outbreaks of canker, the disease caused by the organism in doves and pigeons, have been reported from Mourning Doves, *Zenaida macroura,* in the United States (Stabler, 1954; Greiner and Baxter, 1974). This study was conducted to collect data on the prevalence of *T. gallinae* infection in the Mourning Doves of Central California.

The study site location was in Madera County 5 miles north of Fresno. Natural food consisted of harvested wheat stubble and roadside vegetation. Water sources in the area were irrigation canals (within one mile) and puddles from drip irrigation.

Birds were trapped in July and August of 1986 by methods similar to those described by Dyer (1969). Wheat was used for bait as suggested by Carpenter (1970). Best trapping results were obtained in a harvested wheat field.

Doves caught were weighed and measured and had age and sex determined as outlined in the 1977 *Bird Banding Manual* (USFWS, 1977). Mucous material was collected from the mouth and crop of each bird for microscopic examination following the method described by Stabler (1951a). In addition, two tubes of Diamond's CPLM medium with horse serum and antibiotics were innoculated with sterile swabs which had been passed deep into the throat and applied behind the palatal flaps of each bird. Cultures were incubated at 37° C and examined microscopically for flagellates 24–48 hours after innoculation. Processing of individual birds required no more than 10 minutes. Each bird was banded with a USFWS band and released.

A total of 55 Mourning Doves were trapped. Of these 45 (82%) were in their hatching year while 9 (16.4%) were adult. The age of the remaining bird could not clearly be determined.

Twenty-one of the 55 birds, or 38%, were found infected with *Trichomonas gallinae* by either or both diagnostic methods used (Table 1). Nineteen of the infected birds were juveniles and 1 was adult. The bird of undetermined age was also infected.

TABLE 1. ***Trichomonas gallinae*** **Infection in Central California Mourning Doves, by Age Class.**

AGE CLASS	*TOTAL EXAMINED*	*TOTAL INFECTED*	*PERCENTAGE INFECTED*
Hatch Year	45	19	42%
After Hatch Year	9	1	11%
Undetermined	1	1	100%
All Birds	55	21	38%

In a similar study carried out by Stabler (1951a) in Colorado, *T. gallinae* was found in 23% of Mourning Doves examined. In contrast to the present work, however, Stabler reported no difference in infection rate between adults and juveniles. His results might easily be explained on the basis of the mechanism of transmission of infection. Columbid birds pass the parasite from parent to offspring in the nest. Thus, one might expect comparable infection rates in the two age classes if all offspring of infected parents become infected themselves.

The disparity in parasite prevalence between the age classes (42% vs. 11%) in the present study might be the result of fledged juveniles having moved into the study area from the area where they were hatched after becoming independent of their parents. Thus, the two age classes on the study site in July and August might have represented different nesting populations. In support of this idea it should be noted that juveniles represented more than 80% of the birds examined in the present study. Schultz and Winston (1960) and Lehner (1965) interpret disparity in proportions of age classes in Mourning Dove populations studied by them as the result of early juvenile migration and not the result of local nesting success. Further banding studies in the present area would be useful in coming to a conclusion on this problem.

None of the Mourning Doves in the present study showed evidence of current or previous disease caused by *T. gallinae*. Stabler (1948a, 1951b) reported considerable variation in pathogenic ability of strains isolated from both Domestic Pigeons, *Columbia livia,* and Mourning Doves. His assay for pathogenicity was the effect a parasite isolate had when innoculated into the mouth of a Domestic Pigeon from a *Trichomonas* free loft. No similar tests were done with parasites isolated in the present study. Stabler, however, found an exact correlation between evidence of disease in Mourning Dove donors and degree of pathogenicity in the experimentally infected pigeons. Thus, it is assumed that the parasites found in the present study were of an avirulent strain. The presence of this strain in Central California Mourning Doves may be of particular significance since Stabler (1948b, 1951b) also demonstrated that current infection with a strain of low virulence provides protection against disease (but apparently not infection) caused by a strain of greater pathogenic ability.

Support for this project was given by a number of people. The Department of Fish and Game, Fresno, California, graciously granted the use of their funnel traps. Special appreciation is given to Jim and Zelma Austin for the use of their land and facilities.

LITERATURE CITED

Carpenter, J.W. 1970. Food habits of the Mourning Dove in northwest Oklahoma. Masters Degree Thesis. Cornell Univ., Ithaca. 67 pp.

Dyer, J.M. 1973. Evaluation of factors influencing trapping success for Mourning Doves in western Oklahoma. Masters Degree Thesis. Okla. St. Univ. Lib., Stillwater. 58 pp.

Greiner, E.C. and W.L. Baxter. 1974. A localized epizootic of trichomoniasis in Mourning Doves. *Jour. Wildl. Dis.,* 10: 104–106.

Lehner, P.N. 1965. Some observations on the ecology of the Mourning Dove in New York. *N. Y. Fish Game Jour.,* 12(2): 147–169.

Schultz, V. and F.A. Winston. 1960. A note on juvenile Mourning Dove populations at West Palm Beach, Florida. *Jour. Wildl. Mgt.,* 24(1):105–106.

Stabler, R.M. 1948a. Variations in virulence of strains of *Trichomonas gallinae* in Pigeons *Jour. Parasit.* 34: 147–149.

________. 1948b. Protection in pigeons against virulent *Trichomonas gallinae* acquired by infection with milder strains. *Jour. Parasit.* 34: 150–153.

________. 1951a. A survey of Colorado Band-tailed Pigeons, Mourning Doves and wild common pigeons for *Trichomonas gallinae. Jour. Parasit.,* 37: 471–473.

________. 1951b. Effect of *Trichomonas gallinae* from diseased Mourning Doves on domestic pigeons. *Jour. Parasit.,* 37: 473–478.

________. 1954. *Trichomonas gallinae:* A review. *Exp. Parasit.,* 3: 368–402.

United States Fish and Wildlife Service. 1977. *North American Bird Banding Manual, Vol. II.* Canadian Wildl. Ser., Pop. and Surveys Div., Ottawa, Ontario.

—David J. Rupiper and Wallace M. Harmon, Department of Biology, California State University, Fresno, CA 93740. *Accepted for publication May 1988.*

NEW RECORDS AND RANGE EXTENSIONS OF SHRIMPS AND CRABS FROM CALIFORNIA, U.S.A. AND BAJA CALIFORNIA, MEXICO

While identifying and sorting specimens at the United States National Museum of Natural History (USNM), the California Academy of Sciences (CAS), and the Allan Hancock Foundation (AHF), University of Southern California, I found specimens of two species of crabs and eight species of shrimps that either had not been reported previously for California or represented range extensions in the area of California and Baja California. I thank Dustin Chivers, California Academy of Sciences; Janet Haig, Allan Hancock Foundation; and Raymond B. Manning, Smithsonian Institution, for helping me in examination of the collections. This work was sponsored in part through a Visiting Fellowship of the Smithsonian Institution.

First Records for California

Family Penaeidae

Solenocera mutator Burkenroad, 1938

Previous recorded range.—Southern Baja California, Mexico to Bay of Panama (Burkenroad 1938).

New records.—CALIFORNIA: 6 mi. off Santa Barbara Point (lat 34° 15′N, long 119° 45′W), 190 m, 22 Jan. 1961, W. Dahlstrom, 2 specimens. Off El Segundo (lat 33° 53′N, long 118° 24′W), 55–57 m, gray-green sand, 6 May 1940, *VELERO III* sta. 1141-40, 1 specimen. Off Redondo Beach (lat 33° 49′N, long 118° 25′W), 92–185 m, 8 June 1940, J. and T. Burch sta. 4064–4065, 1 specimen. Los Angeles County, off Bluff Cove (lat 33° 48′N, long 118° 24′W), 139–185 m, 13 July 1940, J. and T. Burch sta. 40107, 2 specimens. Los Angeles County, off Portuguese Point (lat 33° 44′N, long 118° 22′W), 30–37 m, sand and sea weed, 6 May 1940, *VELERO III* sta. 1143-40, 1 specimen. 10 mi. SE of Long Beach (lat 33° 36′N, long 118° 03′W) 59–96 m, mud and fine sand, 22 July 1940, *VELERO III* sta. 1159-40, 2 specimens. 11.5 mi. SE of Long Beach (lat 33° 36′N, long 118° 06′W), 41–52 m, mud, sand and shells, 22 July 1940, *VELERO III* sta. 1160-40, 1 specimen. 3.5 mi. off Newport Beach (lat 33° 34′N, long 117° 59′W), 63–68 m, gray-green mud, 9 Aug. 1940, *VELERO III* sta. 1168-40, 1 specimen. Laguna Beach, off Abalone Point (lat 33° 32′N, long 117° 48′W), 52–54 m, mud, 21 April 1940, *VELERO III* sta. 1130-30, 2 specimens. Laguna Beach, off Abalone Point (lat 33° 30′N, long 117° 47′W), 100–105 m, mud, 21 April 1940, *VELERO III* sta. 1131-40, 3 specimens. Santa Catalina Island, 1.5 mi. SE of W end (lat 33° 27′N, long 118° 36′W), 74–92 m, sand and mud, 4 May 1941, *VELERO III* sta. 1311-41, 1 specimen. Santa Catalina Island, E. of Long Point (lat 33° 24′N, long 118° 21′W), 65–85 m, mud, 5 July 1940, *VELERO III* sta. 1153-40, 1 specimen. Santa Catalina Island, Long Point to Willow Cove (lat 33° 22′N, long 118° 21′W), 55–83 m, sand and algae, 14 Sept. 1941, *VELERO III* sta. 1407-41, 1 specimen. Santa Catalina Island, 0.5 mi. E of Abalone Pt. (lat 33° 20′N, long 118° 19′W), 81–85 m, mud and kelp, 12 June 1941, *VELERO III* sta. 1356-41, 1 specimen. MEXICO, BAJA CALIFORNIA: Isla Guadalupe, Melpomene Cove (lat 29° 15′N, long 118° 50′W), 8 Dec. 1946, Carl L. Hubbs sta. H46-153, 2 specimens. Isla Cedros, E of N end (lat 28° 23′N, long 115° 12′W), 11 m, trawled, 19 Oct. 1971, *SEARCHER* sta. 242, 3 specimens. Isla Cedros, S of N end (lat 28° 20′N, long 115° 10′W), 12 m, trawled, 19 Oct. 1971, *SEARCHER* sta. 243, 1 specimen. E of Isla Cedros (lat 28° 20′N, long 115° 05′W), 91 m, trawled, 19 Oct. 1971, *SEARCHER* sta. 244, 19 specimens. Off Point Rompiente (approx. lat 27° 37′N, long 114° 52′W), 37 m, trawled, 21 Oct. 1971, *SEARCHER* sta. 256-258, 4 specimens; all AHF.

Family Hippolytidae

Heptacarpus pugettensis Jensen, 1983

Previous recorded range.—Alki Point, Seattle, Washington; Brown Island, San Juan Archipelago (Jensen 1983).

New record.—CALIFORNIA: near Morro Bay, Hazard Reef (lat 35° 25′N, long 120° 50′W), −1.0 ft. low tide, 3 June 1969, A. Havens, 4 ov. females, AHF.

Northern Range Extensions

Family Hippolytidae

Heptacarpus taylori (Stimpson, 1857)

Previous recorded range—San Francisco Bay, California to Magdalena Bay, Baja California (Schmitt 1921).

New record.—CALIFORNIA: Dillon Beach, (lat 38° 15′N, long 122° 58′W), sand and rock, shore, 20 Oct. 1948, R. J. Menzies sta. 1626-48, 16 specimens, AHF.

Family Tymolidae

Clythrocerus decorus Rathbun, 1933

Previous recorded range.—Off Santa Rosa Island, to off Point Loma, California (Rathbun 1937).

New records.—CALIFORNIA: Monterey County, off Soberanes Point (lat 36° 27′N, long 121° 56′W), 185 m, 21 July 1971, R. V. *SEARCHER,* D. Chivers and party, 2 specimens. Off Soberanes Point, 185 m, 22 July 1971, D. Chivers and party, 1 specimen. All CAS.

Remarks. One of the specimens taken on 21 July 1971 carried a sponge in its hind legs. This behavior has been reported before in *Clythrocerus planus* (Wicksten 1982).

Southern Range Extensions

Family Hippolytidae

Eualus lineatus Wicksten and Butler, 1983

Previous recorded range.—Sitka, Alaska to Santa Catalina Island, California; Bahia San Gabriel, Isla Espiritu Santo, Gulf of California, Mexico (Wicksten and Butler 1983).

New record.—MEXICO, BAJA CALIFORNIA: Bahía de Todos Santos, Punta Banda (Carvacho and Olson 1984, as *E. subtilis* new species).

Remarks.—The type specimen of *E. subtilis* was not available for examination. However, the description and illustration of *E. subtilis* indicate clearly that the specimen falls within the range of variation of *E. lineatus* Wicksten and Butler. The depth and habitat are similar to that reported for the species previously. *Eualus subtilis* Carvacho and Olson, 1984 therefore is synonymized with *E. lineatus* Wicksten and Butler, 1983. The record given by Carvacho and Olson represents the first report of the species from northern Baja California.

Heptacarpus fuscimaculatus Wicksten, 1986

Previous recorded range.—Santa Rosa Island, California to Guadalupe Island, Baja California (Wicksten 1986).

New record.—MEXICO, BAJA CALIFORNIA: off Thurloe Head (lat 27° 37′N, long 114° 51′W), 15–19 m, rock, 9 March 1934, *VELERO III* sta. 283-34, 1 ov. female, USNM.

Remarks.—This is the first record of the species from the coast of Baja California.

Heptacarpus stimpsoni Holthuis, 1947

Previous recorded range.—Sitka, Alaska to San Diego, California (Schmitt 1921); Bahía de Todos Santos, Baja California (Carvacho and Olson 1984).

New record.—MEXICO, BAJA CALIFORNIA: Bahía Rosario (lat 29° 54′N, long 115° 48′W), 28 m, sand and kelp, 29 Feb. 1937, *VELERO III* sta. 610-37, 4 specimens, USNM.

Lebbeus lagunae (Schmitt, 1921)

Previous recorded range.—Pacific Grove, California to Punta Banda, Baja California (Wicksten and Mendez 1982); Bahía de Todos Santos, Baja California (Carvacho and Olson 1984).

New record.—MEXICO, BAJA CALIFORNIA: Cedros Island, South Bay (lat 28° 05′N, long 115° 21′W), 18–28 m, rock near kelp, 10 March 1934, *VELERO III* sta. 287-34, USNM, 2 specimens.

Family Paguridae

Pagurus tanneri (Benedict, 1892)

Previous recorded range.—Iliuliuk Harbor, Unalaska to off San Simeon Bay, California (Schmitt 1921).

New records.—CALIFORNIA: San Miguel Island, 5.7 mi. off Pt. Bennett (lat 33° 57′N, long 120° 29′W), 406–474 m, 28 April 1976, *VELERO IV* sta. 24886, 1 specimen, AHF. Santa Rosa Island, 13.7 mi. off South Point (lat 33° 40′N, long 120° 07′W), 786–868 m, 23 April 1976, *VELERO IV* sta. 24810, 1 specimen, AHF. San Diego, 11 mi. off Point Loma Light House (lat 32° 40′N, long 117° 30′W), 3 May 1904, *ALBATROSS* sta. 4317, 1 specimen, USNM.

Range Extension North and South

Heptacarpus pictus (Stimpson, 1871)

Previous recorded range.—Monterey Bay to San Diego, California (Schmitt 1921; as *Spirontocaris picta*); Bahía de Todos Santos, Baja California (Carvacho and Olson 1984).

New records.—CALIFORNIA: San Mateo County, San Francisco Bay, Coyote Point (lat 37° 35′N, long 122° 19′W), under rocky ledges, −0.1 foot tide, 18 Feb. 1978, Mary K. Wicksten, 3 specimens, AHF. San Mateo County, Moss Beach (lat 37° 32′N, long 122° 32′W), shore, 18 Nov. 1945, 1 specimen, CAS. San Mateo County, Pigeon Point (lat 37° 12′N, long 122° 25′W), shore, 7 May 1969, D. Chivers, 2 specimens, CAS. MEXICO, BAJA CALIFORNIA: off Thurloe Head (lat 27° 37′N, long 114° 51′W), 15–19 m, rock, 9 March 1934, *VELERO III* sta. 283-34, 1 specimen, USNM.

Remarks.—I have observed and photographed this species at Pigeon Point, Pillar Point, and the James V. Fitzgerald Marine Refuge in Moss Beach, San Mateo County, during 1980–87. The species is common in rocky tidepools.

LITERATURE CITED

Benedict, J. E. 1892. Preliminary descriptions of thirty-seven new species of hermit crabs of the genus *Eupagurus* in the U.S. National Museum. Proc. U.S. Nat. Mus., 15: 1–26.

Burkenroad, M. J. 1938. The Templeton Crocker Expedition XIII. Penaeidae from the region of lower California and Clarion Island, with descriptions of four new species. Zoologica, 23: 55–91.

Carvacho, A. and R. Olson. 1984. Nuevos registros para la fauna carcinológica del noreste de México y descripcion de una nueva especie: *Eualus subtilis,* n. sp. (Crustacea: Decapoda: Natantia). Southwest. Nat., 29: 59–71.

Holthuis, L. B. 1947. The Decapoda of the Siboga expedition Part IX: the Hippolytidae and Rhynchocinetidae. Siboga Expeditie, 39a. 100 p.

Jensen, G. C. 1983. *Heptacarpus pugettensis,* a new hippolytid shrimp from Puget Sound, Washington. J. Crust. Biol., 3(2): 314–320.

Rathbun, M. J. 1933. Preliminary descriptions of nine new species of oxystomatous and allied crabs. Proc. Biol. Soc. Wash., 46: 183–186.

________. 1937. The oxystomatous and allied crabs of America. U.S. Natl. Mus. Bull., No. 166: 1–272.

Schmitt, W. L. 1921. The marine decapod Crustacea of California. Univ. Calif. Publ. Zool., 23: 1–470.

Stimpson, W. 1857. On the Crustacea and Echinodermata of the Pacific shores of North America. J. Boston Soc. Nat. Hist., 6: 444–532.

________. 1871. Notes on Northern American Crustacea in the museum of the Smithsonian Institution. No. III. Ann. Lyc. Nat. Hist. N.Y., 10: 92–136.

Wicksten, M. K. 1982. Behavior in *Clythrocerus planus* (Rathbun, 1900) (Brachyura, Dorippidae). Crustaceana, 43(3): 306–308.

________. 1986. A new species of *Heptacarpus* from California, with a redescription of *Heptacarpus palpaptor* (Owen) (Caridea: Hippolytidae). Bull. So. Calif. Acad. Sci., 85(1): 46–55.

________, and T. H. Butler. 1983. Description of *Eualus lineatus* new species, with a redescription of *Heptacarpus herdmani* (Walker) (Caridea: Hippolytidae). Proc. Biol. Soc. Wash., 96(1): 1–6.

________, and M. Mendez. 1982. New records and new species of the genus *Lebbeus* (Caridea: Hippolytidae) in the eastern Pacific Ocean. Bull. So. Calif. Acad. Sci., 81(3): 106–120.

—Mary K. Wicksten, Department of Biology, Texas A&M University, College Station, Texas 77843. *Accepted for publication April 1988.*

DISTRIBUTION AND ABUNDANCE OF YOUNG-OF-THE-YEAR WHITE SEABASS, *ATRACTOSCION NOBILIS,* IN THE VICINITY OF LONG BEACH HARBOR, CALIFORNIA IN 1984–1987

The white seabass, *Atractoscion nobilis,* is the largest croaker occurring off the coast of California. This important species grows to lengths of 152 cm (5 ft) and to weights of 37.7 kg (83 lbs) (Miller and Lea 1972). White seabass have long been a highly sought-after sport and commercial species in California and, especially, in southern California waters (Frey 1971). This fish is taken primarily by the commercial gill net, rod and reel, and spear-gun fisheries. In recent years the landings of this important species have continued to decline to the point that the populations now appear to be severely impacted (Vojkovich and Reed 1983). Despite its historical economic importance, we know very little about the early life history stages of white seabass. Moser et al. (1983) described the larval development of white seabass from laboratory reared eggs, larvae and juveniles. Field investigations into early life history stages are limited to reports of larval occurrence within CalCOFI collections. Between 1950 and 1978 white seabass larvae were collected in 104 samples with the highest concentrations of larvae being in the Sebastian Viscano Bay and San Juanico Bay regions off Baja California. Only fifteen percent of the larval white seabass occurrences were in southern California waters (Moser et al. 1983). This research note presents information on the distribution and abundance of the critical young-of-the year (YOY) stage of white seabass in the vicinity of Long Beach Harbor, California. This area has been sampled continuously since 1983 as part of a study investigating recruitment patterns in YOY California halibut (Allen 1988). This note will present information on YOY white seabass including their: (i) distribution within the various habitats of the study area, (ii) size range, (iii) depth of capture, (iv) microhabitat specificity, and (v) temporal variation in recruitment in the four years of our study, 1984–1987.

YOY white seabass were captured using 2 m beam trawls (1984) and 2 m otter trawls (1985–87) with 4 mm knotless mesh in the wings and 2 mm mesh in the codends. Both nets yielded statistically comparable catches (t-test, $t = 0.001$, $p > 0.05$) over sand-mud bottoms. A total of 276 tows was made in shallow water (1.5–6.5 m) in the following locations: (i) within Alamitos and Anaheim Bays (protected habitats, $N = 98$), (ii) within eastern Long Beach Harbor and along the eastern portion of Seal Beach (semi-protected habitats, $N = 116$), and (iii) along Sunset Beach (exposed habit, $N = 62$). Stations were occupied during the spring-summer period (March through September) of each year (the actual months varied from year to year). Each station consisted of five, 3 minute tows in most cases. The unit of effort was the mean number of YOY white seabass taken in the five replicate tows per station. It was necessary to combine the replicates in this manner to minimize the number of zeros for subsequent statistical analysis.

A total of 56 white seabass YOY were collected in the semi-protected and exposed portions of the study area over the 4-year period (Figure 1). YOY white seabass were never collected before May in any of the four years of the study, therefore, only tows taken after May are considered in this analysis. No YOY white seabass were ever collected in the 93 tows made in the protected bays. The semi-protected habitats yielded a mean catch-per-unit-effort (CPUE) of 0.39 ± 0.20 individuals (grand mean ± 2 S.E.). Exposed coast tows yielded a mean CPUE of 0.27 ± 0.18 individuals. These differences in the distribution of YOY white seabass among the three habitats was statistically significant (Kruskal-Wallis test, H= 10.18, df= 2, p <0.01). When only the tows from the semi-protected and exposed areas habitats (where YOY occurred) are considered the total mean CPUE of YOY white seabass over the four years of investigation was 0.35 ± 0.14 (N= 23).

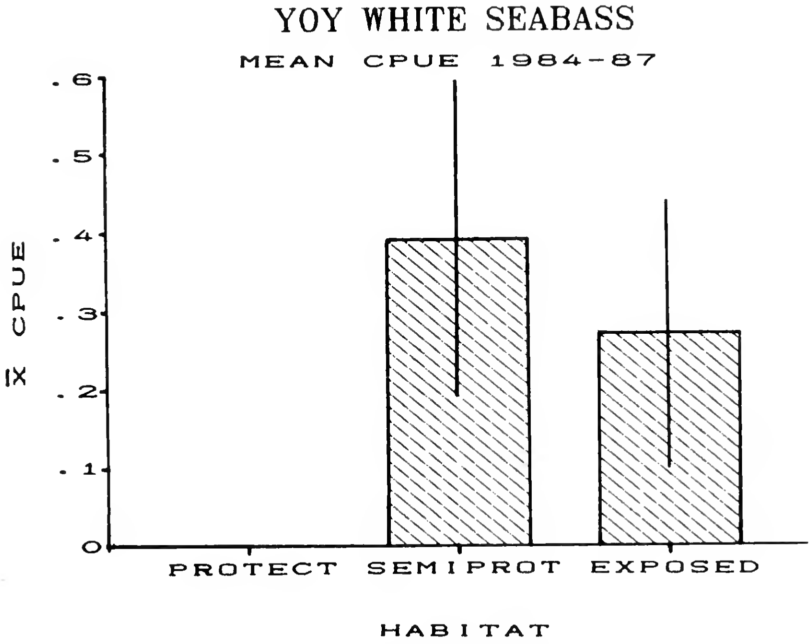

FIGURE 1. Grand mean (± 2 S.E.) catch-per-unit-effort (CPUE) of YOY white seabass within each of the three types of habitats in the vicinity of Long Beach Harbor over the four-year period, 1984–87.

The individual YOY captured ranged from 7–84 mm SL and averaged 28.8 mm SL. Newly recruited individuals seemed to range from 7–10 mm SL. Depth of capture varied between 1.5 and 6.4 m and averaged 3.8 m. Young white seabass were invariably collected with various species of drift algae including browns and reds, clumps of sessile invertebrates (e.g., ectoprocts), and/or debris of terrestrial origin. Often individual fish collected with red algae exhibited a slightly reddish tinge to their body coloration. Likewise, fish captured with golden-brown kelps displayed a slightly golden tinge to their basic dark-barred color patterns.

Apparently, YOY white seabass were utilizing a very specific microhabitat within the study area. They occupied the shallow water areas along the semi-protected and exposed beaches, just outside the wave base where debris and drift algae tend to concentrate. The variance to mean ratios for individual stations within the semi-protected and exposed areas ranged from 0.41 to 1.71

and generally exceeded 1.0. This high variability of individual catches even within the areas known to contain YOY indicates a highly clumped distribution pattern which is probably related to the patchy occurrence of drift algae and other debris. The dark coloration and vertical bars displayed by these small juvenile fish probably serve to camouflage them in this specific microhabitat.

Recruitment of YOY white seabass to the two shoreline habitats of the study area was highly variable during the 4-year study (Figure 2). Abundance (mean CPUE ± 2 S.E.) was highest in 1984 (0.40 ± 0.25; N= 6) and 1985 (0.40 ± 0.24; N= 10) followed by 1987 (0.35 ± 0.41; N= 4). Recruitment to the study area in 1986 (.07 ± .13; N= 3) was relatively low. The differences in yearly recruitment strength, however, were not statistically distinguishable (Kruskal-Wallis test, H= 2.42, df= 3, p> 0.05) due to variable catches within years.

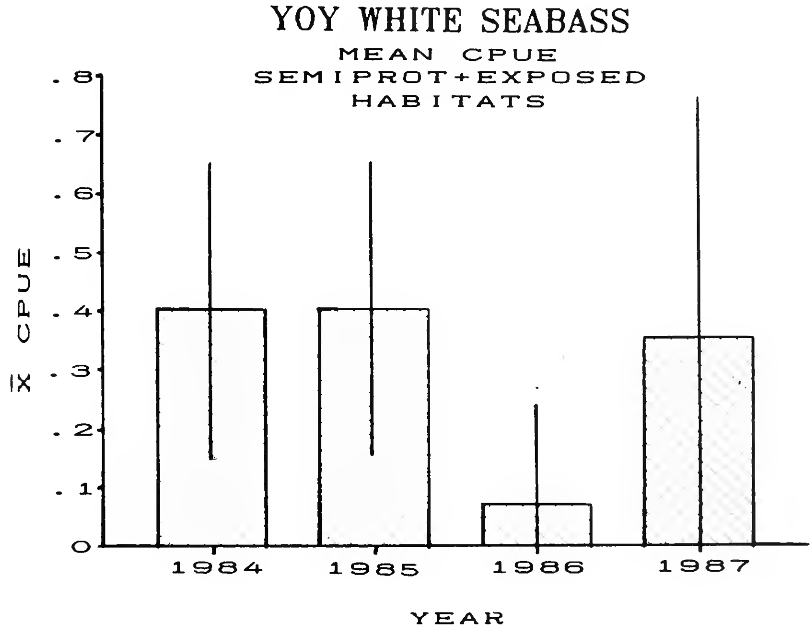

FIGURE 2. Yearly grand mean (± 2 S.E.) catch-per-unit-effort (CPUE) of YOY white seabass within semi-protected and exposed habitats in the vicinity of Long Beach Harbor, 1984–87.

The causes of the variable recruitment are unknown at this time. However, it seems clear that the study area is near the northern limit of white seabass distribution. The main breeding populations occur in the waters off of northern and central Baja California (Moser et al. 1983, Vojkovich and Reed 1983). White seabass recruitment to coastal habitats in southern California is probably heavily dependent on the strength and persistence of northward flowing, warm-water currents during the late spring and summer from year to year. The nature of the relationship between oceanographic features (e.g., current patterns and temperature regimes) and recruitment success remains to be determined by future investigations.

Both young white seabass and California halibut recruited to and utilized the nearshore waters in the Long Beach Harbor area as nursery grounds. However, the two species exhibited a marked difference in microhabitat preference. YOY halibut were found in greatest concentrations in the calm, relatively warm waters of protected habitats such as Alamitos Bay and Anaheim Bay. Halibut also occurred in low concentrations in semi-protected waters (Long Beach Harbor and Seal Beach) within the study area, but were completely absent from the exposed habitat along Sunset Beach (Allen 1988). The distribution of YOY white seabass was almost the mirror image of the distribution of halibut with respect to the three types of habitats. The highest concentrations of young white seabass were found in the semi-protected and exposed habitats. YOY white seabass were conspicuously absent from the protected areas (bays) preferred by YOY halibut.

We thank all those people who assisted in the field work, especially Lucienne Bouvier, Carlos Herrera, Bob Jensen, Rhonda Murotake, Bob Scott, Jon Sloan, and John Zoeger. The crew of the R/V YELLOWFIN, Jim Cvitanovich, Danny Warren, and Dennis Dunn, assisted greatly through their capable handling of vessels in shallow waters. Kevin Herbison (Southern California Edison Co.) was very supportive throughout the course of the work. Lastly, we gratefully acknowledge the financial support from the following agencies: Southern California Edison Company, Marine Review Committee, and the Los Angeles County Fish and Game Commission.

LITERATURE CITED

Allen, L.G. 1988. Abundance, distribution, and dietary habits of young-of-the-year California halibut *(Paralichthys californicus)* in the vicinity of Alamitos Bay- Long Beach Harbor, 1983–1985. Bull. So. Cal. Acad. Sci., 87(1):19–30.

Frey, H.W. ed., 1971. California's living marine resources and their utilization. Calif. Dept. Fish Game, 148 p.

Miller, D.J. and R.N. Lea. 1972. Guide to the coastal marine fishes of California. Calif. Calif. Fish Game, Fish Bull. 157, 235 p.

Moser H.G., D.A. Ambrose, M.S. Busby, J.L. Butler, E.M. Sandknop, B.Y. Sumida, and E.G. Stevens. 1983. Description of early stages of white seabass, *Atractoscion nobilis,* with notes on distribution. CalCOFI Rep., Vol. XXIV: 182–193.

Vojkovich, M. and R.J. Reed. 1983. White seabass, *Atractoscion nobilis,* in California-Mexican waters: status of the fishery. CalCOFI Rep., Vol. XXIV: 79–83.

—Larry G. Allen and Michael P. Franklin, Department of Biology, California State University, Northridge, CA 91330 and Ocean Studies Institute, California State University, Long Beach, CA 90840. Contribution No. 57 from the Ocean Studies Institute. Accepted for publication May 1988.

BOOK REVIEWS

BIRDS OF THE GREAT BASIN: A NATURAL HISTORY

by Fred A. Ryser, Jr. 1985. University of Nevada Press (Reno, NV), xv and 604 p., cloth $29.95 and paper $19.95.

This book, which has pencil drawings by Jennifer Dewey, is one of the first in the Max C. Fleischmann Series in Great Basin Natural History. Other books of the series which have been published describe trees, fishes, geology, and shrubs of the Great Basin. Books in preparation will describe butterflies, ecology and life zones, reptiles and amphibians, and mammals of the Great Basin. The mammal book is being prepared by Professor Ryser.

Fred Ryser is emeritus professor of biology and emeritus curator of the Museum of Biology at the University of Nevada, Reno. He was a faculty member in the Department of Biology at UNR for over 30 years. As he points out in the Acknowledgments section of *Birds of the Great Basin,* much of his knowledge of birds in the geographical area covered by this book has come from his graduate students in ornithology (one of whom is the reviewer) and from birders and professional biologists.

The Great Basin, as described in *Birds of the Great Basin,* is that area of internal drainage (for the most part) which is the northern part of the Basin and Range Province. It includes most of Nevada, significant parts of Oregon and Utah, and small parts of California and Idaho. The western boundary is generally the Sierra Nevada. Included as "Great Basin" in California are Modoc County's Alkali Lakes (but not Goose Lake), Lassen County's Eagle Lake and Honey Lake, and Mono Lake.

The main part of this book is arranged into the following chapters: 1. The Great Basin: birds and environment. 2. The fire of life. 3. The water of life. 4. The diversity of birds. 5. through 16. annotated species accounts for divers through perching birds. Chapter 1 describes the environments available to birds in the Great Basin, of which there are the following three general types: desert, mountain ranges, and wet areas. Chapter 2 is a discussion of homeothermism and description of how birds deal with heat and cold stress in the Great Basin, which subjects its inhabitants to extremes of temperature. Chapter 3 describes how birds deal with water loss and water stress, and describes the sources of water in the Great Basin.

Chapter 4 on diversity discusses the classification of birds in general and specifically describes recent common and scientific name changes by the American Ornithologists' Union. The next 12 chapters contain the annotated species accounts for all birds known from the Great Basin. Here is the real substance of this book, occupying 487 of the 604 pages. Each avian family is discussed briefly. The species accounts contain a combination of general biology/natural history facts and specific detail on occurrence of the species in the Great Basin. The author continually refers to observations on Great Basin birds made by Robert Ridgway in the 1860's. Ridgway was the zoologist for the United States Geological Exploration of the Fortieth Parallel, an expedition headed by geologist Clarence King to explore a railroad route along that parallel. For about two years from 1867–1869 Ridgway collected and observed birds in the Great Basin. Professor Ryser gives the Indian names for some species. For example, the Paiutes called the Sage Sparrow "Tok'-et-se-whah" and the closely related Black-throated Sparrow "Wut'-tu-ze-ze". The author states that Ridgway considered the latter name to be echoic, i.e., it nearly expresses the notes of the song of the Black-throat.

An appendix is entitled "Birding in the Great Basin". This section describes in detail two routes for birding across the Great Basin. These are Interstate 80 from Salt Lake City through Elko and Winnemucca to Reno, with side trips to the Ruby Mountains and other areas; and Highway 50 from Delta, Utah, across central Nevada to Carson City. The author points out that some of the least known spots in the Great Basin, ornithologically speaking, are the montane areas of Nevada's north-south ranges. It was only recently that the significant migration routes for raptors along the Goshute Range and other ranges in the eastern Great Basin were discovered. The appendix suggests specific birding adventures and challenges the reader to add to ornithological knowledge of the Great Basin by focusing on some unanswered questions. The book ends with a Literature Cited section of 513 references.

This book has interest and value not only to those of us who have lived and studied birds in the Great Basin, but also to those who would travel and work there. I echo the author's sentiment about the great need for ornithological research in the Great Basin. For those readers who are interested in the status of endangered species in the Great Basin, there are complete accounts of such birds as the Bald Eagle, Peregrine Falcon, and Yellow-billed Cuckoo. *Birds of the Great Basin* will be of interest to wildlife biologists in agencies and academic institutions in all Great Basin states. I also can recommend it to the nonprofessional (birder or enthusiast) as an easily read wealth of information on many of the birds of the western United States.

—John Gustafson

MONTEREY PENINSULA DIVE GUIDE

by Ed Cooper and Martha Hogan. Available from: Waterline Publications, P.O. Box 51811, Pacific Grove, CA 93950. 1987. 72 p. $5.95 soft cover.

This handy book contains information on SCUBA diving sites in the Monterey area, from the Breakwater to Point Lobos and selected sites along the Big Sur coast to the south. Although at first glance this may seem a rather restricted geographic coverage, the majority of sport diving along the entire central coast of California occurs in the Monterey area, giving this book a very large potential audience.

Information on each site includes a rating (novice, intermediate, advanced), access to the site, a general description of the shoreline adjacent to the site, plant and animal life to look for while underwater, and any specific precautions to heed. There are also numerous photographs and maps which will help those unfamiliar with the areas to find the sites and orient themselves.

The information on each site is accurate and pertinent for a safe, enjoyable dive. From the 2 pages of acknowledgements at the front of the book, it is clear that the authors also consulted with many local divers, as well as drawing on their own experience.

In addition to the specific dive sites, the book also contains information on diving safety, the recompression chamber in Pacific Grove, potentially hazardous marine life (including sharks) in the Monterey area, boat diving, wreck diving, regulations pertinent to diving, collecting, and fishing, underwater photography, and even places to stay and eat.

This book should find its way into many divers' gear bags. It would be invaluable to first-time divers in the Monterey area, as well as to the experienced Monterey diver looking for a new site to explore. The last page of the guide alludes to future editions of the Dive Guide, which if they retain the quality of the first edition should be looked forward to with great anticipation.

—James M. Watanabe

DISTRIBUTION OF THE BIRDS OF CALIFORNIA

by Joseph Grinnell and Alden H. Miller. Cooper Ornithological Society, Berkeley, Calif. 1944. Reprinted by Artemisia Press, P.O. Box 119, Lee Vining, Calif. 93541. 617 p., cloth $25 and paperback $18.

First published in 1944, and long out-of-print, it is a pleasure to see this landmark volume once more available. Comprehensive in its species coverage, it is encyclopedic in its details of distribution of California's extensive avifauna. Subspecies are given full, separate accounts and distribution maps are provided for many species and their races. Each species account includes synonyms, status, geographic range and habitat. The latter are marvelously succinct and a pleasure to read. With the great changes brought about in the California environment and consequent avifaunal shifts, this volume is the benchmark against which to plot those changes, past, present and future.

A scarce work, hard to find outside of libraries, Artemisia Press is to be congratulated on making this indispensable volume again available to the ever increasing number of students of California birds. It is an essential component of any collection of books on California birdlife. Many copies of the original edition have developed brittle paper. This new printing will allow worn out copies to be replaced. It is offered in both hard cover and paperback.

—Alan Baldridge

INDEX TO VOLUME 74

AUTHORS

SUBJECT

SCIENTIFIC NAMES

Photoelectronic composition by
CALIFORNIA OFFICE OF STATE PRINTING

88 78139

INSTRUCTIONS TO AUTHORS

EDITORIAL POLICY

California Fish and Game is a technical, professional, and educational journal devoted to the conservation and understanding of fish and wildlife. Original manuscripts submitted for consideration should deal with the California flora and fauna or provide information of direct interest and benefit to California researchers and managers. Authors should submit the original manuscript plus two copies, including tables and figures.

MANUSCRIPTS: Authors should refer to the *CBE Style Manual* (Fifth Edition) and a recent issue of *California Fish and Game* for general guidance in preparing their manuscripts. Some major points are given below.

1. *Typing*—All text submitted, including headings, footnotes, and literature cited must be typewritten doublespaced, on white paper. Papers shorter than 10 typewritten pages, including tables, should follow the format for notes. Letter quality computer print-out is acceptable.

2. *Citations*—All citations should follow the name-and-year system. The "library style" is used in listing literature cited.

3. *Abstracts*—Every article must be introduced by a concise abstract. Indent the abstract at each margin to identify it.

4. *Abbreviations and numerals*—Use approved abbreviations as listed in the *CBE Style Manual.* In all other cases spell out the entire word.

TABLES: Each table should be typewritten with the heading margin left justified. Tables should be numbered consecutively beginning with "1" and placed together in the manuscript following the Literature Cited section. Do not double space tables. See a recent issue of *California Fish and Game* for format.

FIGURES: Consider proportions of figures in relation to the page size of *California Fish and Game*. The usable printed page is 117 by 191 mm (4.6 by 7.5 in.). This must be considered in planning a full page figure, for the figure with its caption cannot exceed these limits. Photographs should be submitted on glossy paper with strong contrasts. All figures should be identified with the author's name in the upper left corner and the figure numbers in the upper right corner. Markings on figures should be made with a blue china marking pencil. Figure captions must be typed on a separate sheet headed by the title of the paper and the author's name.

PROOF: Galley proof will be sent to authors approximately 60 days before publication. The author has the ultimate responsibility for the content of the paper and is expected to check the galley proof carefully.

PAGE CHARGES AND REPRINTS: All authors will be charged $35 per printed page and will be billed before publication of manuscripts. Reprints may be ordered through the editor at the time the proof is submitted. Authors will receive a reprint charge schedule along with the galley proof.

POSTMASTER: RETURN POSTAGE GUARANTEED
Editor, *CALIFORNIA FISH AND GAME*
CALIFORNIA DEPARTMENT OF FISH AND GAME
1416 NINTH ST., SACRAMENTO, CA 95814

BULK RATE
U.S. POSTAGE
PAID
Sacramento, Calif.
Permit No. 949