The Resources Agency of California
DEPARTMENT OF FISH AND GAME

SALINITY TOLERANCES FOR SALTON SEA FISHES[1]

JACK A. HANSON[2]
Inland Fisheries Branch

SUMMARY

Salinity tolerances were determined for bairdiella (Bairdiella icistius), orangemouth corvina (Cynoscion xanthulus), and sargo (Anisotremus davidsoni). In 96-hour shock bioassays, over half the bairdiella died at salinities 55 and 57.5°/oo, and only 2 of 30 survived at 62.5. Most orangemouth corvina survived to 57.5°/oo, but all died at 62.5. Significant numbers of sargo died at all levels from 45 through 57.5°/oo, and all died at 62.5. Survival of sargo in the controls was only 89.6%, suggesting that some mortality was caused by other factors.

Bairdiella, given an opportunity to adjust to hypersalinity, survived for eight days at 58°/oo.

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[2]Now with Region 2, California Department of Fish and Game.

The Salton Sea is a large, shallow body of water lying approximately 233 feet below sea level in southeastern California. Since its formation its surface elevation and salinity have fluctuated.[3/] From 1950 to 1956 the total dissolved solids approximated those of the oceans. Many fishes were introduced from the Gulf of California during this period (Walker, 1961). Three became established quickly: bairdiella, orangemouth corvina, and sargo. These three species support an estimated 359,000 angler trips annually, with a harvest of 346,000 orangemouth corvina, 307,000 bairdiella, and 195,000 sargo (Robert G. Hulquist, Calif. Dept. of Fish and Game, pers. comm.). More recently the salinity has increased to a high of 39°/oo, recorded in October 1968. Salinites exhibit an annual cycle, with the highest level occurring in fall and winter. Walker (1961) estimated that the fishery could be destroyed sometime between 1980 and 1990 if the gradual increase in salinity was allowed to continue; however, specific information was unavailable on the salinity tolerances of the important fishes and invertebrates of the Sea. Therefore, the California Department of Fish and Game began a study in 1966 to determine salinity tolerances of fishes and food chain organisms as a basis for recommending target levels for a control plan. This paper covers the bioassay work on salinity tolerances of bairdiella, orangemouth corvina, and sargo. Other reports will describe the salinity tolerances of the pileworm (Neanthes succinea), the egg and larval stages of the fishes, and the effects of high salinity on growth.

Small fish were seined at five locations around the Sea (Sandia, Salton Bay, Desert Shores, Whitewater, and State Park Headquarters) and transported to the laboratory in Salton City. Laboratory methods generally followed those outlined in "Standard Methods for the Examination of Water and Wastewater" (American Public Health Association, 1965). Fish were acclimated to laboratory conditions in circular fiberglass tanks containing approximately 175 gallons of Salton Sea water filtered through spun glass and activated charcoal. Constant water temperatures of 23 C (± C) were maintained by room air conditioning and heating units. Specimens were acclimated from 6 to 15 days, depending on survival and overall condition. The lot was deemed fit for testing when mortalities dropped below 10% per day for 4 days. Fish being acclimated received daily rations of frozen shrimp, live brine shrimp, or freeze-dired tubifex worms.

Test concentrations were prepared by slow evaporation of Salton Sea water in large open containers. Table 1 gives chemical analyses of Salton Sea water at three different concentrations. Salinities were measured in the laboratory with a Beckman RC16B2 conductivity bridge.

Tests were conducted in 20-gallon glass and stainless steel aquaria. The water in each aquarium was recirculated through subsand or spun glass and activated charcoal filters. Dissolved oxygen levels were maintained between 4 and 6 ppm. Five to 10 fish were tested in each aquarium. Controls were run concurrently, and all tests were conducted in duplicate.

Two types of tests were performed on bairdiella. The first was a 96-hour shock bioassay in which the fish were put directly into higher salinities after the normal acclimation period. The second was an 8-day bioassay following acclimation to higher salinities. Orangemouth corvina and sargo were subjected only to the 96-hour shock bioassays.

[3/] For details, see Walker (1961) and Pomeroy and Cruse (1965).

TABLE 1

Ionic Composition of Salton Sea Water at Three Different Salinities[1/]

Total dissolved residue by evaporation (ppm)	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl	F	B	SiO_2
38,220	960	864	11,500	220	24	146	7,000	17,750	6.4	8.4	4
69,556	920	1,680	22,500	370	45	265	12,000	35,500	11.0	20	7.5
129,772	880	3,360	35,000	650	66	482	23,000	63,900	21	36	13

[1/] Sample taken November 2, 1967, from surface at Rivera Keys. Analysis by Edward S. Babcock and Sons Laboratory, Riverside, California.

All young-of-the-year bairdiella survived for 96 hours at 52.5°/oo, compared to 60% of the yearlings (Table 2). At 55°/oo, 40% of both groups lived. Survival increased slightly to 43.8% of young bairdiella at 57.5°/oo. Nearly all yearlings died at 62.5°/oo.

All young-of-the-year orangemouth corvina survived at 52.5°/oo. Mortalities were insignificant at 55 and 57.5°/oo. Thereafter, non survived.

Young-of-the-year sargo died in all salinities ranging from controls (38°/oo) to 62.5°/oo. Survival was 78.6% in 47.5°/oo and only 15% in 50°/oo, but was 58.5, 42.9, and 33.3% in 52.5, 55, and 57.5°/oo, respectively. At 62.5°/oo none survived.

It was possible to acclimate yearling bairdiella to 58°/oo by increasing the salinity gradually. For 24 hours, after this level was reached, survival was 100% (Table 3). Thereafter, survival decreased gradually to 82.9% until the test ended 8 days later.

Virtually no work on the salinity tolerances of the Salton Sea fishes had been reported. However, Simmons (1957) found sciaenids in the upper Laguna Madre of Texas to be fairly resistant to hypersalinity. Spotted sea trout, Cynoscion nebulosus, occurred at levels up to 75°/oo. Silver perch, Bairdiella chrysura, were found in 45°/oo, and croakers, Micropegon undulatus, were numerous to 70°/oo. Several other members of the family were found in the range 45 to 50°/oo. Carpelan (1961) found California corbina, Menticirrhus undulatus in Los Penaquitos Lagoon, California, at 51°/oo.

My tests suggest that bairdiella and orangemouth corvina are probably as tolerant to hypersalinity as their Gulf Coast relatives. Bairdiella tolerated salanities above 50°/oo without benefit of acclimation. When given the opportunity to adjust, they survived salinities as high as 58°/oo. Orangemouth corvina tolerated salinities as high as 57.5°/oo and this probably could be increased if they were acclimated.

Sargo's ability to tolerate hypersalinity is less certain. Apparently they do not adapt to laboratory conditions as well as bairdiella and orangemouth corvina, since some died at all salinities and in the controls. However, 78.6 and 58.5% survived in 47.5 and 52.5°/oo, respectively, indicating that they can tolerate 50°/oo.

The results of these tests and the observations of Simmons (1957) and Carpelan (1961) must be interpreted with caution in relation to a salinities control project. They do not mean that the fishery could survive at these high levels. The egg and larval stages are more sensitive to hypersalinity than older stages. Simmons (1957) reported that spotted sea trout did not spawn at levels above 45°/oo and, although croakers were present up to 70°/oo, they probably did not spawn. Significantly, bairdiella immediately began to secrete mucus heavily in salinities above 45°/oo, and they lost equilibrium at 50°/oo, indicating serious physiological stress at these levels. Stresses caused by hypersalinity are apt to be reflected in poor growth rates. Kinne (1960) showed that hypersalinity retarded the growth of the desert pupfish, Cyprinodon macularius. Further studies are under way to assess the effects of high salinity on growth.

TABLE 2

Percentage Survival After Exposure to High Salinities for 96 Hours
(Number of Fish in Parentheses)

Species	Salinity												
	40.0	42.5	45.0	47.5	50.0	52.5	55.0	57.5	62.5	65.0	67.5	75.0	Control
Bairdiella													
Young	100 (10)	--	--	100 (10)	--	100 (10)	40.0 (10)	43.8 (105)	--	--	--	--	100 (30)
Yearlings	--	--	100 (10)	--	--	60.0 (5)	40.0 (5)	--	6.7 (30)	--	--	0.0 (5)	100 (20)
All bairdiella	100 (10)	--	100 (10)	100 (10)	--	86.7 (15)	40.0 (15)	43.8 (105)	6.7 (30)	--	--	0.0 (5)	100 (50)
Orangemouth corvina													
Young	--	--	100 (5)	100 (5)	--	100 (10)	93.3 (15)	91.4 (35)	0.0 (10)	--	--	--	100 (20)
Sargo													
Young	--	85.7 (14)	50.0 (14)	78.6 (14)	15.0 (60)	58.5 (41)	42.9 (7)	33.3 (21)	0.0 (7)	--	--	--	89.6 (48)

TAPLE 3

Percentage Survival of Bairdiella Acclimated to 58°/oo

Day	Survival	
	Number	Percentage
1	35	100
2	34	97.1
3	33	94.3
4	31	88.6
5	31	88.6
6	30	85.6
7	29	82.9
8	29	82.9

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