ASPECTS OF THE BIOLOGY OF THE SHINER PERCH IN A SOUTHERN CALIFORNIA ESTUARY

Dan B. Odenweller
California Department of Fish and Game
Stockton, California

Abstract. The life history of the shiner perch, Cymatogaster aggregata, in Anaheim Bay, California is reviewed. The shiner perch is a member of the family Embiotocidae, and ranges from Port Wrangell, Alaska to Bahia Todos Santos, Baja California.

The study area is a coastal salt marsh, located in the northwestern corner of Orange County, California, in Seal Beach and Sunset Beach. The area encompasses approximately 102,000m^2, and is located wholly within the confines of the U.S. Naval Weapons Station, Seal Beach.

Cymatogaster aggregata lives approximately two and one half years in Anaheim Bay. Annual and monthly growth rates indicated slopes of 8.82 and 5.12 respectively. These growth rates are extremely high and were confirmed by instantaneous growth rate calculations.

Feeding takes place continuously, and the primary source of food is zooplankton. During periods of low zooplankton abundance, the shiner perch turns to benthic organisms as its principal source of food.

The population of Cymatogaster aggregata studied in Anaheim Bay appears to be limited by a temperature maximum of 18.5 C, less than the maximum temperature range reported for the species.

The shiner perch is primarily preyed upon by birds, and several have been confirmed as predators. Several fish may also utilize the shiner perch as a food source. Only one parasite, Livoneca sp., a cymothid, was found during the course of the investigation.

INTRODUCTION

The shiner perch, Cymatogaster aggregata Gibbons, is a member of the family Embiotocidae. The species ranges from Port Wrangell, Alaska to Bahia Todos Santos, Baja California, encompassing the entire eastern Pacific distribution of the family Embiotocidae. Commonly taken by sportfishermen, shiner perch have slight commercial value, primarily as bait (Tarp, 1952). First described by Gibbons (1854), the taxonomy of the genus and species has remained constant to this date, with only one additional species Cymatogaster gracilis, described (Tarp, 1952).

Embiotocids are amphipacific in distribution, with 21 representative species in the eastern Pacific and two species in Japanese and Korean waters. Only two embiotocid species, Rhacochilus vacca Girard and Embiotoca lateralis L. Agassiz, are as widely distributed as the shiner perch (Tarp, 1952).

Age and growth of shiner perch from Puget Sound, Washington, was discussed by Suomela (1931), while the life history of Cymatogaster in British Columbia was studied by Gordon (1965). Boothe (1967) reviewed food and feeding of four species of fish, including the shiner perch, from San Francisco Bay, California, and finally, Anderson and Bryan (1970) discussed age and growth of three embiotocids, including shiner perch, from Humboldt Bay, California.

The viviparous mode of reproduction present in the Embiotocidae has been the subject of a great deal of investigation since it was first described by Agassiz (1853). A good deal of this work has been done by Wiebe (1968a, 1968b, 1968c, 1968d, 1969a, 1969b), primarily on the modification for a viviparous mode of reproduction.

Miller (1943) reported predation on Cymatogaster by Caspian terns, Hydroprogne caspia, and Hubbs, et al. (1970) records the same predation by Brandt's cormorant, Phalocrocorax penicillatus.

MATERIALS AND METHODS

Collections for this study were made between April, 1970 and March, 1971, during bi-weekly trawling operations. The collection schedule consisted of two daylight collections, followed by a day-night sampling sequence, covering all stages of tidal fluctuation.

Collection gear was a shrimp otter trawl. This trawl measured 4.9 m in width at the mouth, and 11.9 m, from the cork line to the cod end, including a 1.2 m bag. It was equipped with a tickler chain and weighted otter boards (measuring 0.4 m by 0.7 m). The trawl was constructed of 3.71 cm stretch mesh (1.85 cm bar) nylon netting at the throat, the cod end consisting of 2.54 cm stretched mesh (1.27 cm bar) nylon netting, protected by chafing gear. The netting was treated with "Net Set," giving it a black color. A 0.63 cm woven nylon liner was added to the cod end of the trawl on May 3, 1970 after it became apparent the smaller fish were not being adequately sampled. The trawl was towed with a 14-foot skiff powered by an 18 horsepower motor. Trawls were three minutes in duration at a speed of approximately two knots, except occasionally when net fouling shortened the time.

Specimens collected during this study were preserved using 4 percent for*maldehyde (10 percent formalin) in sea water solution, and preserved in 40* percent isopropyl alcohol for later use.

Measurements are as described in Hubbs and Lagler (1947). These were taken before and after preservation, so the effects of preservation could be determined. Specimens were measured to the nearest millimeter and weighed to the nearest tenth of a gram, after blotting away all excess preservative. These specimens were used for length-weight, age structure, growth, food and feeding, sex ratio and fecundity determinations. Further discussion of materials and methods will be given in those sections where they directly apply.

ENVIRONMENTAL DESCRIPTION

General Area

Anaheim Bay is located in the northwestern end of Orange County, California, in Seal Beach and Sunset Beach. The bay consists of an outer deepwater harbor, and an inner bay composed of a series of dredged channels and a tidal salt marsh. The inner bay is composed of four major arms. The southern arm, Huntington Harbour, has been developed into an area of canal side homes and marinas. The remaining three arms are located in the United States Naval Weapons Station, Seal Beach, and are relatively undeveloped, having remained essentially unchanged since 1875.

Study Area

The study area is located in the "middle arm" of the inner bay, it has an area of approximately 102,000m^2 and is totally within the confines of the Naval Weapons Station. Three trawl stations were established, each approximately 200 m in length.

Tidal movements are generally predictable, the major source of variation being the result of the high winds. Low tides expose a great number of mudflats, occasionally emptying the upper reaches of the channels above the stations. Each station has a channel of such depth that it is permanently submerged. High tides partially overflow the banks of the channels, while Spring high tides flood the grassflats completely.

LENGTH-WEIGHT

The length-weight relationship of Cymatogaster aggregata was calculated using a random sample of 230 individuals. The relationship is curvilinear, and is described by the equation:

$$W = 4.91 \times 10^{-4} L^{3.05}, \text{ or}$$

$$\text{Log } W = 3.05 \text{ Log } L + 5.69119 - 10,$$

where W = weight after preservation, and L = length after preservation. The equation complies with the formula $W = aL^b$ given in Ricker (1958), and the power term (b = 3.05) indicates isometric growth.

Parker (1963) reported shrinkage attributable to preservation in 4 percent formaldehyde and sea water solution to range between 2 and 4 percent loss in length. Shrinkage was computed for 92 fish, and averaged 4.7 percent.

The relationship between total length (T.L.) and standard length (S.L.), is defined by the equation:

$$\text{T.L.} = 1.26 \text{ S.L.} + 1.73 \quad (r = 0.99)$$

The relationship between otolith length and standard length also yielded a straight line, defined by the equation:

$$\text{Otolith length} = 0.05 \text{ S.L.} + 0.48 \quad (r = 0.98)$$

AGE AND GROWTH

Cymatogaster aggregata have been recorded to an age of two and one half years in Anaheim Bay. Age determinations were based on otolith aging and a Peterson length frequency plot, substantiated by aging a random scale sample. Length grouping was performed using the criteria established by Andersen (1964). Otoliths were manually cleaned and stored in water for later use. Aging was done using the reflected light technique described by Gambell and Messtorff (1964). Otoliths were immersed in oil of anise, using the black-bottomed dish described by Schott (1965). Scales were taken from the right dorsal surface, above the lateral line, on a vertical line through insertion of the pectoral fin. Scales were manually cleaned and mounted between two glass slides for reading. A total of 229 pairs of otoliths were aged, and compared to a sample of 50 scales, selected with a table of random numbers. Total agreement on age determinations was reached in all cases.

The presence of a birth check in the scales of _Cymatogaster aggregata_ was noted by Suomela (1931) and Gordon (1965). Carlisle, et al. (1960) reported the presence of a birth check in scales of the barred surfperch, _Amphistichus argenteus_. A birth check was present in all scales and otoliths of _Cymatogaster_ studied during the course of this investigation.

Fish in their first year ranged in length between 31 and 87 mm standard length, the mean being 56.8 mm. The second year class ranged from 68 to 115 mm standard length, with a mean of 87.8 mm. The third age class ranged between 81 and 117 mm standard length, with a mean of 100.6 mm. A logarithmic transformation of these values was made, and a line was fitted through the points. The resulting line is expressed by the equation:

$$\text{Log } Y = 8.82 \text{ Log } X - \text{Log } 17.14$$

The slope of this line indicated a rapid annual growth rate for _Cymatogaster_ in Anaheim Bay.

Monthly estimates of growth were obtained by arbitrarily establishing January 1 as the date fertilization took place in the shiner perch. This decision was based on a published account that fertilization takes place in December (Eigenmann, 1894) and also on the Gonosomatic Index for fish from Anaheim Bay. Each fish was then given an age based on the date of capture. Thus, a fish taken in August, three months after birth, would be termed a 0 + 8, or eight month old fish. The mean size for each monthly period was then plotted, and a line fitted to the points. This line is described by the equation:

$$Y = 5.12\ X + 33.98$$

This analysis again yielded a slope indicating a high growth rate. It should be noted that there appears to be more rapid growth from June to December, the warmer time of the year, than January to May. The different slopes found in the two methods may be due to the first being an annual rate over three age classes, and the second being a monthly rate over one year.

Average daily instantaneous growth rates were computed using the same methods as Gordon (1965), so a comparison between shiner perch from British Columbia and Anaheim Bay could be made. The rate for fish from southern California begins at about the same level as for those from British Columbia, but remains higher over a year, substantiating the previously mentioned high growth rates, whereas there is a rapid decrease in rates for the British Columbia fish. This difference may be attributable to a combination of warmer waters and greater food abundance in Anaheim Bay.

The use of instantaneous growth rate calculations described by Ricker (1958) showed that there is a rapidly decreasing increment of weight with increasing age. The values derived from the equation:

$$g = \text{Log}_e(Wt/Wo),$$

where g = instantaneous growth rate, Wo = weight at start of time, and Wt = weight at the end of the time period (1 year), are 0.55 for the 0-1 year period, and 0.15 for the 1-2 year period.

FOOD FEEDING

Food and feeding analysis was based on 138 samples, selected randomly from the semi-monthly collections. The digestive tract was removed from each fish, and the position of the food was noted. A visual estimate of the percentage of the total volume in the tract occupied by various food organisms in each section was noted. The contents of the entire tract were then emptied into a small glass dissecting dish and examined under a binocular microscope. The food organisms were identified and placed in the general categories; algae (Enteromorpha sp. and Ulva sp.), polychaetes, gastropods (Tegula sp. and Olivella sp.), pelecypods (Mytilus edulis), eggs of the topsmelt (Atherinops affinis), which are associated with a benthic habitat, and zooplankton, which are generally considered to be free floating organisms. The zooplankton were identified to order or subclass and placed under two general headings; the first being large zooplankton which included amphipods, mysids, ostracods, caprellids, large copepods and small shrimp. The second heading was small zooplankton under which were grouped small copepods and the larval stages of crustaceans. After the food organisms were identified and grouped, an estimate of the approximate percentage each group made up of the total food volume.

The data were grouped by sexes, age, season and diet period. The only variation in diet appears to be seasonal in nature, and can be seen in Table 1.

TABLE 1

DIET COMPOSITION FOR THE SHINER PERCH BY SEASONS

	Spring	Summer	Fall	Winter
Detritus	31.0%	18.3%	18.8%	20.1%
Empty	18.5	0.0	9.4	0.0
Zooplankton				
Large Zooplankton	30.4	65.7	54.9	25.5
Small Zooplankton	6.5	4.0	10.6	3.5
Total Zooplankton	36.9	69.7	65.5	28.7
Benthic				
Pelecypod	1.3	5.3	2.3	8.7
Gastropod	1.1	0.0	0.9	2.8
Polychaete	1.1	0.0	1.6	5.5
Tunicate	0.0	0.0	0.0	0.8
Fish Eggs	5.0	0.0	0.0	2.7
Algae	1.7	0.0	0.0	0.8
Total Benthic	10.2	5.3	4.8	21.3
Diptera	3.7	6.7	1.6	0.1

Seasons were delineated by temperature data, and thus, spring encompassed April, May and June; summer lasting through July August and September. Fall consisted of October, November and December, while winter encompassed January, February and March.

The prime source of food for Cymatogaster in Anaheim Bay appears to be zooplankton. During summer and fall, periods of high zooplankton abundance, this item composes 60 percent of the diet of the shiner perch. During winter, when low plankton abundance exists, there appears to be a diet shift, and perhaps a change in the method of feeding. During this period the diet is more varied, and 50 percent of the stomach contents are mud and detritus. This would indicate that Cymatogaster is feeding on or in the substrate with a resultant high amount of debris. Spring appears to be a transitional period, with the highest percentage, nearly 20 percent, of empty stomachs. This rich environment allows Cymatogaster to feed continually, and may explain the remarkably high growth rates this species attains in Anaheim Bay.

BIRTH AND FECUNDITY

The sex ratio for Cymatogaster aggregata in Anaheim Bay was determined from 1234 specimens. Of these, there were 590 males and 644 females. This ratio was tested against a 1:1 sex ratio using the Chi Square test of significance, and no significant difference was found.

The onset of birth for the shiner perch in Anaheim Bay was determined from catch data, and by computing the Gonosomatic Index. The Gonosomatic Index (GSI) is an index of gonad development, and has been defined as:

$$GSI = \frac{\text{Gonad weight (gms)}}{\text{Body weight (gms)}} \times 100$$

and is expressed as a percentage (Weibe, 1968d).

The first indication of the presence of young shiner perch was in April, and the bulk of the young were born in May. The GSI confirms these data, and shows May as the point where birth takes place. This is in marked contrast to the time of birth in more northern waters. Wiebe (1968d) plotted the GSI for fish in British Columbia and showed July as the month in which Cymatogaster was born. This difference in time of birth can be attributed to the warmer temperatures and higher growth rate in Anaheim Bay.

Gordon (1965) calculated the average number of embryos carried by mature Cymatogaster females in British Columbia. He concluded that there was a tendency for the number of embryos to increase as body length increased. The same date for southern California was computed, and reflects a similar trend.

THERMAL LIMITATION

The shiner perch has been reported to be eury-thermal, with a temperature range of 4 to 21 C (Tarp, 1952). The population studied in Anaheim Bay appeared to be limited by a temperature somewhat below the recorded maximum for the species. The first indication of this limitation came from catch data for the months of June, July and August of 1970. On days when the water temperature exceeded 18.5 C, the catch in the middle fell off markedly.

This observation was confirmed in the laboratory, when aquaria in which some shiner perch were being maintained accidentally exceeded 18.5 C or slightly above it, the fish went into stress, and began dying. Within five days, all fish in the aquaria had died. The dissolved oxygen level never fell below 7.0 parts per thousand. This evidence though not conclusive, would seem to indicate the presence of a thermal barrier for the population which may be somewhat more conservative than that for the species as a whole. No attempt was made to establish the critical thermal minimum for the population.

PREDATORS AND PARASITES

Shiner perch predators have seldom been recorded in the literature. The only records of predators are birds, the Caspian tern, Hydropogne caspia, recorded by Miller (1943), and Brandt's cormorant, Phalocrocorax penicilliatus, recorded by Hubbs, et al. (1970).

The only confirmed predators this study found were gulls, family Laridae, and the least tern, Sterna antillarum. Table 2 is a list of possible predators compiled from data presented by Fritz (1970).

TABLE 2

LIST OF POSSIBLE PREDATORS

Mustelus californicus	Grey smoothound
Paralichthys californicus	California halibut
Porichthys myriaster	Slim midshipman
Ardea herodias	Great blue heron
Hydranassa tricolor	Louisiana heron
Nycticorax nyctocorax	Black-crowned night heron
Larus argentatus	Herring gull
Larus californicus	California gull
Larus delawarensis	Ring-billed gull
Larus heermanni	Heermann's gull
Larus philadelphia	Bonaparte's gull
Podilymbus podiceps	Pied-billed grebe
Sterna antillarum	Least tern
Sterna maxima	Royal tern
Rallus longirostris	Clapper rail

The only parasite found on the shiner perch in Anaheim Bay was an isopod of the genus *Livoneca* (Cymothidae). This parasite was found in 7 of 1234 fish, or less than one percent of the population. The parasite was attached to either the exterior of the fish, on the tail, or was found in the branchial cavity, attached to the gills.

SUMMARY

The shiner perch, *Cymatogaster aggregata*, is a common species along the coast of California. It is not of great importance, although commonly taken by sportfishermen.

The shiner perch lives approximately two and one half years in Anaheim Bay, and has a very fast growth rate. The annual and monthly estimates of growth from this study indicated slopes of 8.82 and 5.12 respectively when time is plotted against length in millimeters. These are extremely high and probably the result of warm waters and a highly productive environment.

Feeding takes place continuously, with the primary source of food being zooplankton. During periods of low plankton abundance, *Cymatogaster* shifts to a diet of benthic organisms, including pelecypods, gastropods, polychaetes, tunicates and fish eggs.

The time of birth for the shiner perch is earlier than at the northern extreme of its range, again an indication of the warmer, more productive environment.

The shiner perch population in Anaheim Bay, California ranges throughout the bay and appears limited only by high temperature. *Cymatogaster* left the upper reaches of the bay when the temperature began to exceed 19 C. This limit for the population is in contradiction to the temperature range of the species as a whole reported by Tarp (1952) to be 4 to 21 C.

The shiner perch is preyed upon primarily by birds, with several confirmed predators. Several fish may also utilize the shiner perch as food. Only one parasite, a cymothid of the genus *Livoneca* was found on *Cymatogaster aggregata* in Anaheim Bay.

LITERATURE CITED

Agassiz, L. 1853. On extraordinary fishes from California, constituting a new family. Amer. J. Sci. Arts 2(16):380-390.

Anderson, K. P. 1964. Some notes on the effect of grouping data with special reference to length measurements. Danm. Fisk. - og Havunder., Medd. 4(4):79-92.

Anderson, R. D., and C. F. Bryan. 1970. Age and growth of three surfperches (Embiotocidae) from Humboldt Bay, California. Amer. Fish. Soc., Trans. 99(3):475-482.

Boothe, P. 1967. Food and feeding habits of four species of San Francisco Bay fish. Calif. Dept. Fish and Game, MRO Ref. (67-13):151 p. (M.A. Thesis, Univ. Calif., Berkeley).

Carlisle, J. G., Jr., J. W. Schott and N. J. Abramson. 1960. The barred surfperch (Amphistichus argenteus Agassiz) in southern California. Calif. Fish and Game, Bull. (109):79 p.

Eigenmann, C. H. 1894. Cymatogaster aggregatus Gibbons; a contribution to the ontogeny of viviparous fishes. U.S. Fish. Comm., Bull. 12:401-478.

Gambell, R., and J. Messtorff. 1964. Age determination in the whiting (Merlangius merlangus L.) by means of otoliths. J. Cons. 28(3):393-404.

Gibbons, W. P. 1854. Daily Placer Times and Transcript, San Francisco, May 18, 1854. (Cited by Eigenmann, C. H. and A. B. Ulrey, U.S. Fish. Comm., Bull. 12:396).

Gordon, D. C. 1965. Aspects of age and growth of Cymatogaster aggregata Gibbons. M.S. Thesis, Univ. Brit. Columbia. 90 p.

Hubbs, C. L., and K. F. Lagler. 1947. Fishes of the Great Lakes region. Cranbrook Inst. Sci., Bull. (26):213 p.

Hubbs, C. L., A. L. Kelley and C. Limbaugh. 1970. Diversity in feeding by Brandt's cormorant near San Diego. Calif. Fish and Game, 56(3):156-165.

Miller, A. H. 1943. Census of a colony of Caspian terns. Condor 45(6): 220-225.

Parker, R. R. 1963. Effects of formalin on length and weight of fishes. Fish. Res. Bd. Can., J. 20:1441-1455.

Ricker, W. E. 1958. Handbook of computation for biological statistics of fish populations. Fish. Res. Bd. Can., Bull. (119):300 p.

Schott, J. W. 1965. A visual aid for age determination of immersed otoliths. Calif. Fish and Game 51(1):56.

Suomela, A. J. 1931. The age and growth of Cymatogaster aggregata Gibbons, collected in Puget Sound, Washington. M.S. Thesis, Univ. Wash. 43 p. (Unpublished).

Tarp, F. H. 1952. A revision of the family Embiotocidae (surf-perches). Calif. Fish and Game, Bull. (88):99 p.

Wiebe, J. P. 1968a. A technique for gonadectomy in the seaperch Cymatogaster aggregata. Can. J. Zool. 46(3):613-614.

Wiebe, J. P. 1968b. Inhibition of pituitary gonadotropic activity in the viviparous seaperch _Cymatogaster aggregata_ Gibbons by a dithiocarbamoylhydrazine derivative (ICI-33838). Can. J. Zool. 46(4):751-758.

______________. 1968c. The effects of temperature and day-length on the reproductive physiology of the viviparous seaperch _Cymatogaster aggregata_ Gibbons. Can. J. Zool. 46(6):1207-1219.

______________. 1968d. The reproductive cycle of the viviparous seaperch _Cymatogaster aggregata_ Gibbons. Can. J. Zool. 46(6):1221-1234.

______________. 1969a. Steroid dehydrogenases in gonads of the seaperch _Cymatogaster aggregata_ Gibbons. Gen. Comp. Endocrinol. 12(2):256-266.

______________. 1969b. Endocrine controls of spermatogenesis and oogenesis in the viviparous seaperch _Cymatogaster aggregata_ Gibbons. Gen. Comp. Endocrinol. 12(2):267-275.